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CARLETON REA and J. RAMSBOTTOM

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THE BRISTOL FORAY.

April 20th–23rd, 1923.

The 1923 spring foray was held during the week-end April 20th to 23rd at Bristol, where, through the President, Professor O. V. Darbishire, the Botanical Department of the University had been kindly placed at the disposal of the Society.

On the Friday evening, at 8.30 p.m., the members assembled at the University and were received by Professor Darbishire and his assistants. The evening was spent very pleasantly greeting friends and examining the various mycological exhibits in the Department, including excellent bottled specimens of some of the more striking plant diseases. Miss Ida M. Roper had brought a specimen of *Polyporus sulphureus* found growing in a cellar.

On Saturday, April 21st, the party drove by charabanc to Ashton Court. Work in the grounds there yielded a few of the larger fungi, but more in microscopic forms, such as Rusts and Pyrenomycetes. A young ash plantation especially provided some interesting species.

Towards the end of the afternoon the various scattered groups made their way towards the Research Station at Long Ashton, where tea had been provided. Mr Wallace, of the Long Ashton staff, conducted the party over the laboratories and the outdoor experimental plots, and gave some account of the work that was being carried on. Proof was provided of the excellent results of experiment in cider production.

In the evening, at the University, Miss B. M. Breeze read a paper on "The Sterility of the Pollen of the Potato 'Up-to-Date,'" suggesting the possible parasitic nature of certain bodies observed in the pollen-grains.

Nine new members were elected, bringing the total number of members to over 300. Some discussion took place as to the locale of the next spring foray. Dovedale was suggested, with Buxton as a centre, but the Council was empowered to adopt an alternative should this prove impracticable.

On Sunday, April 22nd, two alternative excursions were arranged for the afternoon. Some of the party drove by charabanc to Corsham, near Bath, and were shown over the underground mushroom beds belonging to Messrs Agaric, Ltd. Others, under the leadership of Mr A. A. Pearson, visited Blaise Castle Woods, and added a number of species to the list, which would otherwise have been very scanty for this day. Mr Pearson

obtained a good specimen of *Acia stenodon*, apparently quite rare in this country.

In the old mine workings at Corsham quantities of *Coprinus radians* were found, but little else of note was gathered by that party.

In the evening, Mr F. E. Smith gave an account of some work he had been doing on the fungus *Mycogone perniciosa*. The fungus is a parasite of the cultivated mushroom, and material had been obtained from the beds at Corsham.

Monday, the 23rd, was spent in the woods at Cleeve Combe and Goblin Combe, in the county of Somerset. Here on dead branches in a beech wood *Bertia moriformis* was found abundantly, and in some cases old specimens showed the large spores with up to 6 or 7 septa mentioned by the late Sir Henry Hawley (*Trans. Brit. Myc. Soc.* VIII, p. 227). Another noteworthy find on this day was *Myriangium Duriaei*, which was abundant on scale insects on some young ash trees.

In the evening, Miss Wakefield reported briefly the finding by Mr W. M. Ware of *Helicobasidium purpureum* associated with *Rhizoctonia violacea* on red clover, and in drawing attention to the possibility of a connection between the two fungi she appealed to members present to watch for and to send further specimens of either fungus, especially of the *Helicobasidium*, as cultural experiments were being started.

An additional new member, Dr W. Watson of Taunton School, was elected, and hearty votes of thanks were accorded to the Bristol University authorities for their hospitality and to the various landowners who had given permission for their estates to be visited.

In thanking Professor Darbishire for the trouble he had taken to organise such an interesting and enjoyable meeting, Mr Ramsbottom took the opportunity to convey to him the congratulations of the Society on the birth of a son and heir, the good wishes taking the form of a silver porringer. Professor Darbishire replied.

With this little ceremony the meeting was brought to a close.

The Secretary is indebted to Mr Ramsbottom, Mr Pearson, and Dr Bayliss Elliott for assistance in compiling the subjoined list of species gathered during the Foray.

A = Ashton Court (Somerset). *B* = Blaise Castle Woods (Gloucestershire). *C* = Cleeve Combe and Goblin Combe (Somerset). Corsham records, which are for Wiltshire, are specially indicated.

HYMENOMYCETES.

Tricholoma melaleucum (Pers.) Fr., *B*.
Mycena discopus Lév., *B*.
Clitocybe fragrans (Sow.) Fr., *A*.
Marasmius conigenus (Pers.) Karst., *A*., dryophilus (Bull.) Karst., *B*.

Lenzites betulina (Linn.) Fr., *B.*
Entoloma sericeum (Bull.) Fr., *C.*
Nolanea papillata Bres., *B.*
Pholiota praecox (Pers.) Fr., *A.*
Galera tenera (Schaeff.) Fr., *A.*, hypnorum (Schrank) Fr., *A.*
Bolbitius titubans (Bull.) Fr., *C.*
Paxillus panuoides Fr., *Corsham.*
Hypholoma fasciculare (Huds.) Fr., *A.*, *B.*
Psilocybe foenisecii (Pers.) Fr., *A.*
Psathyrella gracilis (Pers.) Fr., *B.*
Coprinus micaceus (Bull.) Fr., *C.*, radians (Desm.) Fr., *A.*, *Corsham*, stercorarius Fr., *C.*, atramentarius (Bull.) Fr., *B.*
Panaeolus campanulatus (Linn.) Fr., *A.*
Polyporus dryadeus (Pers.) Fr., *C.*, betulinus (Bull.) Fr., *A.*, adustus (Willd.) Fr., *C.*
Fomes annosus Fr., *A.*, *B.*
Polystictus versicolor (Linn.) Fr., *A.*, abietinus (Dicks.) Fr., *B.*, *C.*
Trametes gibbosa (Pers.) Fr., *B.*, mollis (Sommerf.) Fr., *B.*
Merulius corium (Pers.) Fr., *A.* (on ash).
Irpex obliquus (Schrad.) Fr., *C.*
Acia stenodon (Pers.) Bourd. and Galz., *B.*
Odontia fimbriata (Pers.) Fr., *B.*, farinacea (Pers.) Quél., *B.*
Grandinia granulosa Fr., *A.*
Hymenochaete rubiginosa (Dicks.) Lév., *B.*
Stereum hirsutum (Willd.) Fr., *A.*, *C.*
Corticium Sambuci (Pers.) Fr., *A.*, *B.*, *Corsham*, laeve (Pers.) Fr., *A.*, *B.*, *C.*, confine Bourd. and Galz., *B.*, *C.*, comedens (Nees) Fr., *B.*, praetermissum (Karst.) Bres., *B.*
Peniophora longispora (Pat.) v. H. and L., *B.*, cremea Bres., *A.*, setigera (Fr.) Bres., *A.*, hydnoides C. and M., *A.*, *B.*, *C.*, incarnata (Pers.) Cooke, *A.*, cinerea (Fr.) Cooke, *A.*, *C.*, laevigata (Fr.) Mass., *B.*, quercina (Pers.) Cooke, *C.*
Solenia anomala (Pers.) Fr., *C.*
Auricularia auricula-Judae (Linn.) Schroet., *A.*
Exidia glandulosa (Bull.) Fr., *C.*, nucleata (Schw.) Rea, *B.*
Dacryomyces deliquescens (Bull.) Duby, *C.*

GASTROMYCETES.

Phallus impudicus (Linn.) Pers., *A.* ("egg" only).
Bovista plumbea Pers., *C.*
Lycoperdon caelatum (Bull.) Fr., *C.*

UREDINALES.

Uromyces Poae Rabenh., *B.*, *Corsham*, Ficariae Lév., *A.*, Scillarum (Grev.) Wint., *C.*
Puccinia Violae (Schum.) DC., *B.*, *C.*, Umbilici Guép., *A.*, Smyrnii Biv., *A.*, tumida Grev., *B.*, Saniculae Grev., *C.*, Taraxaci Plowr., *Corsham*, Phalaridis Plowr., *A.*, *B.*, Caricis (Schum.) Rebent., *A.*, Buxi DC., *C.*
Phragmidium Fragariastri (DC.) Schroet., *C.*, subcorticium (Schrank) Wint., *A.*, Rubi (Pers.) Wint., *A.*, *C.*
Melampsora Rostrupii Wagn., *A.*, *B.*, *C.*

USTILAGINALES.

Urocystis Anemones (Pers.) Schroet., *B.*

PYRENOMYCETES.

Nectria episphaeria (Tode) Fr., *A.*, *C.*, galligena Bres., *C.*, coccinea (Pers.) Fr., *C.*
Xylaria Hypoxylon (Linn.) Grev., *A.*
Hypoxylon rubiginosum (Pers.) Fr., *C.*, multiforme Fr., *A.*
Daldinia concentrica (Bolt.) Ces. and de Not., *A.*, *B.*
Eutypa lata (Pers.) Tul., *A.*
Diatrype Stigma (Hoffm.) de Not., *A.*, *C.*, disciformis (Hoffm.) Fr., *A.*, *C.*

Diatrypella quercina (Pers.) Nke., *C.*, nigro-annulata (Grev.) Nke., *A.*
Valsa ambiens (Pers.) Fr., *C.*, syngenesia Fr., *A.*
Cryptosphaeria eunomia (Fr.) Fuck., *A.*, *C.*
Anthostoma turgidum Nits., *C.*
Diaporthe occulta (Fckl.) Nke., *A.*
Calospora platanoidis (Pers.) Niessl., *A.*
Fenestella vestita (Fr.) Sacc., *C.*
Lasiosphaeria spermoides (Hoffm.) Ces. and de Not., *A.*
Stigmatea Robertiani Fr., *A.*, *C.*
Leptosphaeria acuta (Moug.) Karst., *A.*
Bertia moriformis (Tode) de Not., *A.*, *C.* (form with eventually up to 6 or 7 septa).
Dichaena quercina (Pers.) Fr., *C.*
Hypospila frustula (Pers.) Wint., *A.*
Mycosphaerella maculiformis (Pers.) Schroet., *C.*

DISCOMYCETES.

Acetabula vulgaris Fuck., *C.*
Disciotis venosa (Pers.) Boud., *C.*
Sarcosphaeria coronaria (Jacq.) Boud., *A.*
Corynella glabro-virens Boud., *C.*
Orbilia xanthostigma Fr., *A.*
Hyalinia Leightoni (Phill.) Boud., *C.*
Chlorosplenium aeruginosum (Oeder) de Not., *C.*
Dasyscypha virginea (Batsch) Fuck., *C.*
Lachnella canescens (Phill.) Cooke, *C.*
Trichoscypha calycina (Schum.) Boud., *A.*
Hyaloscypha hyalina (Pers.) Boud., *B.*, *C.*
Mollisia cinerea (Batsch) Karst., *A.*, *B.*, *C.*
Stegia Ilicis Fr., *B.*
Rhytisma acerinum (Pers.) Fr., *A.*, *C.*
Myriangium Duriaei Mont. and Berk., *C.*

PHYCOMYCETES.

Peronospora parasitica (Pers.) de By, *A.*

SPHAEROPSIDALES.

Phyllosticta hedericola Dur. and Mont., *C.*
Phoma lineolata Desm., *A.*
Phomopsis scobina Grove, *C.*, glandicola Grove, var. Coryli-putaminis Sacc., *C.*
Cytospora nivea Sacc., *C.*
Ceuthospora Lauro-cerasi Grove, *C.*
Septoria Rubi West., *A.*, *C.*, Violae West., *C.*
Discella carbonacea (Fr.) B. and Br., *Corsham.*

MELANCONIALES.

Pestalozzia Guepini Desm., *A.*, on rhododendron.

HYPHOMYCETES.

Trichoderma lignorum (Tode) Harz., *C.*
Isaria farinosa (Dicks.) Fr., *B.*, clavata Ditm., *C.*
Tilachlidium tomentosum (Schrad.) Lind., *B.*

MYCETOZOA.

(Rev. P. J. Alexander, C.J.)

Badhamia capsulifera Berk., *A.*, utricularis Berk., *B.*, panicea Rost., *B.*
Physarum nutans Pers., *B.*, compressum Alb. and Schw., *C.*, vernum Somm., *C.*
Craterium minutum Fries, *A.*, *B.*, *C.*
Leocarpus fragilis Rost., *B.*
Diderma spumarioides Fr., *C.*, hemisphericum Horn., *C.*, radiatum Lister, *B.*
Didymium difforme Duby, and var. connatum Lister, *C.*, squamulosum Fr., *A.*, *B.*, *C.*, melanospermum Macbr., *A.*

Stemonitis fusca Roth., *B.*
Comatricha nigra Schroet. and var. alta Lister, *B., C.*
Brefeldia maxima Rost., *B.*
Dictydiaethalium plumbeum Rost., *B., C.*
Reticularia Lycoperdon Bull., *A., B., C.*
Liceopsis lobata Torrend, *B.*
Lycogala epidendrum Fr., *A., B., C.*
Trichia affinis de Bary, *C.*, persimilis Karst., *A., B., C.*, varia Pers., *A., C.*, decipiens Macbr., *A., B., C.*, Botrytis Pers., *C.*
Hemitrichia clavata Rost., *B.*
Arcyria incarnata Pers., *B., C.*
Margarita metallica Lister, *B.*

THE LICHENS OF THE BRISTOL FORAY.

By W. Watson, D.Sc., A.L.S.

Two of the excursions were to localities where the substratum was mainly a calcareous one. In both localities a number of rock-surfaces were exposed and therefore a fairly large number of calcicolous lichens were noticed. The cliffs, rock-ledges and screes of Cleeve Combe were especially interesting, and yielded a number of lichens characteristic of such habitats. On the Warren above the Combe some leaching had occurred and many ground lichens, more representative of a siliceous district, were present. The only known British locality for *Lecidea testacea* is near Cleeve Combe, but the exact spot, where it is still abundant, was not visited. Cleeve Combe is also one of the two British localities from which *Leptogium placodiellum* is recorded. It is abundant on the talus but very seldom merits Nylander's specific name of *placodiellum*, the thallus rarely showing the radiate lobes distinctly, so that Krempelhuber's specific name of *diffractum* is more appropriate. A number of lichens (*e.g. Collema flaccidum, Thelotrema lepadinum, Urceolaria gypsacea, Lecidea Metzleri, Biatorina candida*), which have been previously seen in the Combe, are not given in the list as they were not observed during our hurried survey. The corticolous lichens were more abundant in the Cleeve district than in the Bristol area, smoke having its usual effect on them. Blaise Castle Woods were rather poor for lichens, they were too damp and the shading was too great. This locality is in Gloucestershire, the other two are in Somersetshire. In none of the localities visited was an altitude greater than 550 feet reached.

A = Ashton Court. *B* = Blaise Castle. *C* = Cleeve Combe. *W.* = Wrington and Wrington Warren.

Calicium hyperellum Ach., *B., W.*
Sphinctrina turbinata (Pers.) Fr., *C.*
Placynthium nigrum (Huds.) Gray, *A., C., W.*
Collema pulposum (Bernh.) Ach., *B., C.*
C. tenax (Sw.) Ach., *A.*
C. cheileum Ach., *A.*

C. multifidum (Scop.) Schaer., *C.*
C. granuliferum Nyl., *C.*
C. terrulentum Nyl., *B.*
Leptogium microscopicum Nyl., *A.*, *C.*
L. minutissimum (Flk.) Fr., *C.*
L. scotinum v. sinuatum (Huds.) Malbr., *C.*
L. lacerum (Lil.) Gray, *A.*, *C.*
L. diffractum Kremp., *C.*, *W.*
Peltigera canina (L.) Willd., *C.*
P. rufescens (Weis.) Hoffm., *C.*
form praetextata (Flk.) Cromb., *C.*
P. polydactyla (Neck.) Hoffm., *B.*, *C.*
P. horizontalis (L.) Hoffm., *C.*
Ramalina calicaris (L.) Fr., *C.*
R. farinacea (L.) Ach., *A.*
R. fraxinea (L.) Ach., *A.*
R. fastigiata (Pers.) Ach., *A.*
U. florida (L.) Web., *C.*
var. hirta (L.) Ach., *A.*
U. ceratina Ach., *B.*
Evernia prunastri (L.) Ach., *A.*, *B.*, *C.*, *W.*
Platysma glaucum (L.) Nyl., *B.*
Parmelia perlata (L.) Ach., *A.*
P. revoluta Flk., *C.*
form minor Harm., *C.*
P. dubia (Wulf.) Schaer., *W.*
P. sulcata Tayl., *A.*, *B.*, *C.*
P. saxatilis (L.) Ach., *A.*, *B.*, *C.*
form furfuracea Schaer., *A.*, *B.*, *C.*
var. panniformis Schaer., *B.*
form caesiopruinosa Nyl., *B.*
P. caperata (L.) Ach., *A.*, *B.*, *C.*
P. fuliginosa Nyl., *A.*, *C.*
form aterrima Nyl., *A.*
var. laetevirens (Flot.) Nyl., *A.*
P. physodes (L.) Ach., *A.*, *B.*, *C.*
form labrosa Ach., *W.*
Physcia ciliaris (L.) DC., *A.*
P. pulverulenta (Schreb.) Nyl., *A.*
P. grisea form pityrea (Ach.), *A.*
P. stellaris (L.) Nyl. form rosulata (Ach.), *A.*
P. aipolia (Ach.) Nyl., *A.*, *C.*
var. cercidia (Ach.) Nyl., *A.*
P. leptalea (Ach.) DC., *A.*
form leptaleodes Nyl., *A.*
P. tenella (Scop.), *A.*
form ascendens (Bitter), *A.*
P. caesia (Hoffm.) Nyl., *A.*
P. virella (Ach.) Lynge, *A.*
Rinodina roboris (Duf.) Arn., *A.*
Buellia canescens (Dicks.) de Not., *A.*, *B.*, *C.*
B. myriocarpa (DC.) Mudd., *A.*
form depauperata (Anzi.), *A.*
form stigmatea (Krb.), *A.*
Xanthoria parietina (L.) Th. Fr., *A.*, *B.*, *C.*
var. aureola (Ach.) Th. Fr., *A.*
Placodium callopismum (Ach.) Mer., *A.*, *B.*
var. plicatum (Wedd.), *A.*, *B.*
P. xantholytum Nyl., *C.*
Callopisma citrinum (Hoffm.) Krb., *A.*, *B.*
C. pyraceum (Ach.) Arn., *A.*
C. rupestre v. calvum (Dicks.), *W.*
form incrustans (DC.), *C.*
Candelariella vitellina (Ehrh.) Mull-Arg., *A.*, *B.*
form corusca (Ach.), *A.*
Crocynia lanuginosa (Ach.) Hue., *B.*
Squamaria saxicola (Poll.) Hook., *A.*, *W.*
Lecanora galactina Ach., *A.*, *C.*
L. rugosa (Pers.) Nyl., *B.*
L. chlarona (Ach.) Cromb., *A.*, *B.*, *C.*
L. campestris (Schaer.) Nyl., *C.*
L. umbrina (Ehrh.) Mass., *A.*
L. Hageni Ach., *A.*
L. atra (Ach.) Huds., *A.*
L. parella (L.) Ach., *A.*
L. varia (Ehrh.) Ach., *B.*
L. expallens (Pers.) Ach., *B.*, *C.*
var. lutescens (DC.) Nyl., *C.*
L. polytropa (Ehrh.) Schaer., *A.*
Aspicilia calcaria (L.) Krb., *A.*
A. gibbosa (Dicks.) Krb., *A.*
Placolecania candicans (Dicks.) Zahl., *W.*
Acarospora fuscata (Schrad.) Th. Fr., *A.*
Pertusaria amara (Ach.) Nyl., *A.*, *B.*, *C.*
P. communis (DC.), *A.*, *B.*, *C.*
var. leiotera Nyl., *C.*
P. leioplaca (Ach.) Schaer., *B.*, *C.*
P. Wulfenii DC., *A.*, *C.*
Phlyctis argena (Ach.) Krb., *A.*, *B.*, *C.*
P. agelaea (Ach.) Krb., *B.*, *C.*
Cladonia pyxidata Fr., *A.*, *B.*, *C.*
var. pocillum Fr., *W.*
C. pityrea (Flk.), *W.*
form hololeois (Flk.) Wain., *W.*
C. fimbriata (L.) Fr., *W.*
var. radiata (Schreb.) Nyl., *B.*
C. ochrochlora Flk., *C.*
C. furcata Hoffm., *W.*
C. rangiformis Hoffm., *W.*
C. sylvatica Hoffm., *W.*
C. Floerkeana f. trachypoda Nyl., *W.*
C. macilenta Hoffm., *A.*, *B.*, *W.*
C. digitata Hoffm., *B.*
Lecidea ochracea (Hepp.) Wedd., *W.*
L. immersa (Web.) Ach., *B.*
L. quernea (Dicks.) Ach., *A.*
L. parasema Ach., *A.*, *B.*, *C.*
var. elaeochroma Ach., *A.*
var. flavens Nyl., *A.*, *C.*
L. protrusa Fr., *A.*

Biatorina synothea (Ach.) Krb., *B.*
B. Griffithii (Sm.) Mass., *W.*
Bilimbia aromatica (Turn.) Jatta., *A.*
Bacidia phacodes Krb., *B.*
B. incompta (Borr.) Anzi., *B.*
Gyalecta truncigena (Ach.) Hepp., *B.*
G. cupularis (Ehrh.) Schaer., *C.*
G. exanthematica Fr., *C.*
Lecanactis premnea (Ach.) Wedd., *A.*
Arthonia radiata (Pers.) Ach., *C.*
var. Swartziana (Ach.) Sydow, *A., B., C.*
Graphis elegans (Borr.) Ach., *A., B., C.*
G. scripta (L.) Ach., *C.*
Enterographa crassa (DC.) Fée., *A., B.*
Opegrapha atra Pers., *A., C.*
O. varia Pers., *A., B., C.*
form diaphora Ach., *B.*
O. vulgata Ach., *B.*
O. saxicola v. Decandollei Stiz., *A.*
Dermatocarpon lachneum f. rufescens (Ach.), *C.*
Verrucaria integra Carr., *A.*
V. rupestris Schrad., *A.*
V. parva Deakin., *A., C.*
V. calciseda DC., *A., C.*
V. marmorea (Scop.) Zahl., *A.*
V. nigrescens Pers., *A., C.*
V. coerulea DC., *C.*
V. glaucina Ach., *A.*
V. viridula (Schrad.) Ach., *C.*
Acrocordia gemmata (Ach.) Krb., *A.*
A. epipolea (Borr.) A. L. Sm., *B., C.*
Porina chlorotica (Ach.) Wain., *B.*
P. carpinea (Pers.) Zahl., *B., C.*
Pyrenula nitida (Weig.) Ach., *A., B. C.*
var. nitidella (Flk.) Mudd., *C.*
Mycoporum miserrimum Nyl., *C.*

A Lecidea and an Arthopyrenia from rocks at Ashton Court have not been determined satisfactorily. The Lecidea may be a variety of *L. protrusa* Fr. The Arthopyrenia approaches *A. saxicola* Mass., but the spores are too large. *Myriangium Duriaei* M. and B., which was formerly put amongst the lichens, was abundant on ash trees in Cleeve Combe. Prof. Darbishire informs me that *Peltigera horizontalis* was abundant in Cleeve Combe and that he found *Scutula epiblastematica* (Wallr.) Rehm. [= *Biatorina epiblastematica* A. L. Sm.] parasitic on *Peltigera rufescens* in the same locality.

OBSERVATIONS ON SOME SCOTTISH UREDINEAE AND USTILAGINEAE.

By Malcolm Wilson, D.Sc., F.R.S.E., F.L.S., Reader in Mycology in the University of Edinburgh.

PUCCINIA CIRSII Lasch.

Uredospores and teleutospores on *Carduus heterophyllus* L. Darnaway, Forres, collected by Greville probably in 1821, and Murthly, Perthshire, Sept. 1921.

Greville's specimen is preserved in the Herbarium of the Royal Botanic Garden, Edinburgh. The species has not been previously recorded on this host in this country, but has been described on it on the continent. The sori are on pale yellowish spots and are exclusively epiphyllous. The teleutospores are distinctly verruculose. *P. Andersoni* B. and Br. occurs on this

host in Scotland, but differs in the absence of uredospores, the hypophyllous sori and the distinctly thickened apex of the teleutospore.

P. Tripolii Wallr.

On *Aster Tripolium* L., Aberlady, Haddington, Sept. 1921.

Only previously recorded in Scotland from the Tay and Dee areas.

P. Sonchi Rob.

This rust appears to be widespread in Scotland. It has already been recorded by Trail from Aberdeen, by Johnson from Berwick and by Boyd in Ayrshire. It was not uncommon near Berwick and in the neighbourhood of Edinburgh in 1922 and was also found by Professor Scott Elliott in Kirkcudbrightshire. In these cases only uredospores were present. Teleutospores were however found on specimens collected at Brantingham near Hull in September 1922, and this appears to be the first occasion on which this spore-form has been found in Britain.

P. paludosa Plowr.

Aecidia on *Pedicularis palustris* L. and uredospores and teleutospores on *Carex Goodenovii* Gay, Taynuilt, Argyll, August 1921, and Lumphanan, Aberdeen, July 1922.

Previously recorded from Norfolk and by Trail from Orkney. Aecidiospores placed on *Carex Goodenovii* on July 24th produced uredo-, and teleuto- and mixed sori on the upper surface of the leaf on August 21st, 1922.

P. mirabilissima Peck.

Uredospores and teleutospores on *Berberis Aquifolium* Pursh., Colinton, near Edinburgh, January 1923, and Newlands, Peeblesshire, July 1923.

This appears to be the first European record of this species which has hitherto only been found in some of the western United States and in Washington (see *Trans. Bot. Soc. Edin.* xxviii, 1923, p. 164).

P. Zopfii Wint.

Uredospores and teleutospores on *Caltha palustris* L., Taynuilt, Argyllshire, July 1921, and Lumphanan, Aberdeen, July 1922.

A Scottish specimen of this rust is preserved in the herbarium of the British Museum (see *Trans. Brit. Myc. Soc.* iv, 1913, p. 185) and its discovery in the localities mentioned above appears to indicate that it is widespread in Scotland. It is also recorded from England and Ireland. It has probably been confused with *P. Calthae* Link but differs from this species in its broader teleutospores.

P. SEPTENTRIONALIS Juel.

This species is frequently found on the higher Scottish mountains at altitudes from 2000–3500 ft., where the host plants, *Thalictrum alpinum* L. and *Polygonum viviparum* L., grow in association. On the continent the uredospore and teleutospore stages have also been recorded on *Polygonum Bistorta* L. This latter species is a typical lowland plant, the greatest altitude at which it has been recorded being 600 ft., while its northern limit is given as Aberdeen—Isle of Skye (Watson, *Cybele Britannica*, vol. II, p. 332). *Thalictrum alpinum* rarely or never descends below 1500 ft. in central Scotland, although it has been found at sea level in the extreme north. It is in consequence highly improbable that *P. septentrionalis* should naturally occur on *P. Bistorta* in this country. In order to determine the susceptibility of the latter species aecidiospores from *Thalictrum alpinum* were placed on the leaves of *P. Bistorta* growing in the Royal Botanic Garden, Edinburgh. In about three weeks typical uredosori of *P. septentrionalis* were produced on the under surface of the leaves.

It must be concluded, therefore, that the non-occurrence of *Puccinia septentrionalis* on *Polygonum Bistorta* in this country is not determined by the immunity of the latter species but by the distribution of the alternative host, *Thalictrum alpinum.*

P. EPILOBII DC.

On *Epilobium obscurum* Schreb. Collected by Miss D. de Watteville, near Kingussie, Inverness. July 1922.

Up to the present *P. Epilobii* has only been described on *Epilobium palustre* in this country. The majority of the specimens in the Edinburgh Herbarium, however, including one collected by Greville in Edinburgh in 1821, appear to be on *E. obscurum*. *E. obscurum* was previously regarded as a sub-species of *E. tetragonum*, and it is noteworthy that a hybrid exists between *E. palustre* and *E. obscurum*. *P. Epilobii* is recorded on *E. roseum* on the continent but not on *E. tetragonum*.

P. GLUMARUM Erikss. et Henn.

Uredospores and teleutospores on *Hordeum murinum* L. Collected by Mr M. Y. Orr, Berwick, October 1922, and by Mr G. B. Wallace, Edinburgh and Pathhead, Midlothian, October 1923.

The rust on *Hordeum murinum* does not appear previously to have been found in Britain. In the specimens a few uredospores are present on the leaves and teleutospores are found on the sheaths; both kinds of spores occur on the glumes. The sori are minute and arranged in indefinite lines. The uredospores are verrucose, oval, 20–34 × 18–23 μ, mean 26 × 21 μ.

The teleutospores are variable in form, clavate, rounded or truncate above where the wall is thickened, slightly constricted and usually attenuated but occasionally rounded below, sometimes curved and sometimes with the pedicel attached rather laterally, 44–48 × 17–23 μ, mean 45 × 21 μ; mesospores are very few 33 × 24 μ; paraphyses few or none.

The question arises as to whether this form should be assigned to *P. Hordei* Fuckel (*Symb. Myc.*, Nachtr. II, 1873, p. 16). Fuckel states that *P. Hordei* is distinguished from *P. straminis* (= *P. glumarum*) by the minute sori, globose, rarely oval, uredospores which are smooth and by the form of the teleutospores; in the latter the upper cell is "more obscure," the lower cell which is about equal to the upper in size is never elongated and possesses a rounded base; the pedicel is attached laterally.

In the present specimens the uredospores are distinctly verrucose and oval in form, the upper cell of the teleutospore is usually the larger and the lower cell is generally attenuated; the base of the latter is usually not rounded. In these respects therefore they differ from *P. Hordei*. The points of resemblance are the small sori and the presence of a few teleutospores with rounded base and lateral pedicel.

Sydow (*Monogr. Ured.*, I, p. 708) and Eriksson and Hennings (*Getreideroste*, p. 238) merge *P. Hordei* in *P. glumarum* and this is followed in the case of the present specimens. The almost complete absence of mesospores distinguishes the specimens from *P. simplex* Erikss. et Henn.

The relationships of this rust must remain doubtful until its powers of infection are known and infection experiments are now being commenced. No such work appears to have been carried out with *P. Hordei*.

P. Anthoxanthi Fckl.

Uredospores and teleutospores on *Anthoxanthum odoratum* L. near Aberdeen, Oct. 1921.

It was suggested in a previous note (*Journ. Bot.* 1915, p. 47) that two distinct rusts had been confused under the above name in this country, and this has now been shown to be the case.

P. Anthoxanthi Fckl. appears to be of rare occurrence, and has not been previously recorded in Scotland although recently recorded from Wales by Grove (*Journ. Bot.* 1921, p. 311). In the Scottish specimens the uredospore sori attain a length of 6 mm. and are produced so abundantly as to give the whole leaf a rusty appearance; they are also found on the leaf sheaths and stems. The uredospores measure 20–25 × 17–20 μ and possess 2–3 equatorial germ-pores; no paraphyses are present in the sorus.

The teleutospore sori are dark brown in colour, linear, and up to 4 mm. long. They are present on the leaves, sheaths, and stems. The teleutospores measure 25–38 × 15–20 μ; mesospores are also present. No paraphyses are found in the teleutospore sorus. The Scottish fungus agrees closely with Fuckel's specimens and with Sydow's specimen in the *Mycotheca Marchica*. It is improbable that this is *P. borealis* Juel, for the specimens were found at a low level (about 400 feet) and the alternative host of this species, *Thalictrum alpinum*, is not found below an altitude of 1000 feet in this neighbourhood, an elevation not attained within 15 miles of the spot where the rust was collected.

The specimens previously assigned to *P. Anthoxanthi* Fckl. (see *Journ. Bot.* 1915, p. 47 and *Trans. Brit. Mycol. Soc.* VII, 1921, p. 83) agree with *Uredo anthoxanthina* described by Bubák (*Ann. Mycol.* III, 1905, p. 223) and differ from *P. Anthoxanthi* Fckl. in the much smaller size of the uredospore sorus which contains paraphyses and in the absence of teleutospores.

Uredo anthoxanthina Bubák appears to be widely distributed in Scotland, and has been discovered in the Tweed, Forth, Tay, and Dee areas and in Argyll and by Boyd in Ayrshire. It has also been found in South Wales and is recorded by Grove from Aberystwyth and in Worcestershire.

A uredo-sorus of this species containing spores capable of germination was found in March on a plant of *Anthoxanthum odoratum* which had been planted out in a garden in Edinburgh in the autumn of 1920 when it was apparently uninfected. It seems probable therefore that this species can survive the winter in the form of mycelium in the leaf. The persistence of the fungus by means of uredospores is not however altogether excluded, as these were present in the late autumn in the locality from which the plant was taken.

Uromyces flectens Lagerh.

Teleutospores on *Trifolium repens*. Ballinluig, Perthshire, Oct. 1921.

This species does not appear to have been definitely recorded in Scotland. It was probably included under *U. Trifolii* (*Scot. Nat.* 1890, p. 304) ("*U. apiculosa*, Lév.") by Trail. The sori are found on elongated swellings on the petioles.

Melampsora reticulatae Blytt.

Uredospores on *Salix reticulata* L. Collected by Dr A. W. Borthwick probably on one of the Perthshire mountains.

Uredo-sori, hypophyllous, small, scattered; uredospores verrucose, angular, ovate or subglobose 20–27 × 17–20 μ with wall about 2·5 μ thick; paraphyses numerous, capitate, 75–100 μ

long, 21–28 μ wide at the widest part of the head, wall up to 9 μ thick.

M. reticulatae is distinguished from *M. alpina* and *M. arctica* by its larger uredospores and paraphyses. It is believed to form its caeoma on *Saxifraga aizoides* (*cf.* Sydow, *Mon. Ured.* III, p. 362).

Although only uredospores are present on the specimen there appears to be no doubt that it is really *M. reticulatae*. This opinion is strengthened by Trail's record of the discovery of a caeoma on *S. aizoides* in Scotland (*Scot. Nat.* 1890, p. 326, under *Caeoma Saxifragae*).

Melampsoridium Alni Diet.

Uredospores and teleutospores on *Alnus glutinosa* Medic. and on *A. incana* Medic., Craibstone, near Aberdeen, Oct. 1922.

M. Alni appears to have been first recorded in this country by C. O. Farquharson in 1911 in the vicinity of Aberdeen (*Ann. Scot. Nat. Hist.* 1911, p. 240). The fungus was found on *A. glutinosa* and identified as *M. betulinum*.

It has recently been recorded by Grove as collected by Boyd in Ayrshire on *A. glutinosa* (*Journ. Bot.* 1921, p. 315).

The present specimens were found on two-year seedlings of *A. incana* grown from foreign seed obtained by the Forestry Commission. A few seedlings of *A. glutinosa* were also infected.

The fungus closely resembles *M. betulinum*. The small, yellow uredo-sori are rather few and are scattered over the under surface of the leaf; the uredospores are usually rather smaller than those of *M. betulinum*. The uredospores of the latter species are stated to be smooth at their apices while those of *M. Alni* are echinulate over the whole surface of the wall but these characters do not appear to be constant for all the spores in either of the species. The teleuto-sori are hypophyllous and very inconspicuous.

Melampsorella Caryophyllacearum Schroet.

Aecidia on *Abies Nordmanniana* Spach., Murthly, Perthshire, March 1923. Collected by Mr J. L. S. Smith.

Producing a small witches' broom similar to those on *Abies pectinata*. Not previously recorded on this host in Britain.

Pucciniastrum Epilobii Otth.

Uredospores on *Epilobium alpinum* L. Collected by Mr J. R. Matthews, Meall nan Tarmachan, Perthshire, June 1922.

The specimens were collected at an altitude of about 3000 ft. The uredo-sori are amphigenous, generally hypophyllous, scattered, very small in size and the rust does not produce any discolouration of the leaf. The peridium has the usual structure. Uredospores echinulate, 20–25 × 15 μ with hyaline epispore.

The orange-yellow uredospores show up conspicuously on the bright green leaves, especially after the sori dehisce and the spores are shed. The latter are produced in great abundance and fall to the ground in powdery masses.

Infected plants were grown for several months in Edinburgh and continued to form numerous uredospores but no teleutospores were produced. Healthy plants of *Epilobium alpinum* were readily infected by placing uredospores on their leaves but all attempts to infect *E. angustifolium* L., *E. obscurum* Schreb., *E. montanum* L., and *E. alsinefolium* Vill., resulted in failure. It appears therefore that we are here dealing with a specialised form which is restricted to *E. alpinum* as host and the name *P. Epilobii* sp. f. *alpinae* is accordingly suggested. The absence of spots on the leaves of the host and the fact that the measurements of the uredospores are slightly greater than those given by Sydow (*Monog. Ured.* III, p. 444) are not considered to be characters of sufficient importance to justify the creation of a new species.

P. Epilobii is recorded on *Epilobium alpinum* by Sydow (*l.c.*). It is also found on *E. alsinefolium, E. montanum* and a number of other species. It is included under *P. pustulatum* Diet. by Grove (*Brit. Rust Fungi*, p. 366). Sydow (*l. c.* p. 443) divides the latter species into: (1) *P. Abieti-Chamaenerii* Kleb. on *E. angustifolium* and other species of the section Chamaenerion which produces numerous teleutospores in obvious sori and has its aecidium on *Abies balsamea* and *A. pectinata*, (2) *P. Epilobii* Otth. on various species of the section Lysimachion with few teleutospores in inconspicuous sori and no known aecidial stage.

No species of *Pucciniastrum* appears to have been previously recorded on *E. alpinum* in Britain.

THECOPSORA VACCINIORUM Karst.

Uredospores on *Vaccinium Myrtillus* L. near Aberdeen, and Ballinluig, Perthshire, Oct. 1921 and on *Vaccinium uliginosum* L. Ben Lui, Perthshire, Sept. 1921.

The uredospore stage appears to be widespread in Scotland on *Vaccinium Myrtillus*. Infected leaves of *V. uliginosum* were kept during the winter on damp soil but did not develop the teleutospores. The fungus has been previously recorded on *V. Myrtillus, V. uliginosum* and on *V. Vitis-Idaea* in Scotland by Trail ("Revision of Uredineae and Ustilagineae of Scotland," *Scot. Nat.* 1890).

COLEOSPORIUM SENECIONIS Fr.

Uredospores and teleutospores on *Senecio Smithii* DC. Collected by Mr Symington Grieve on the island of Coll, Argyllshire, July 1922.

The sori are hypophyllous. The fungus has not been previously described on this South American host species. The *Senecio Smithii* had apparently been growing for some time on the island and no information regarding its origin could be obtained. It is interesting to note that there are no pines on the island and the nearest are more than ten miles distant on the island of Mull. This appears to indicate that the fungus, under these conditions, can exist through the winter in the absence of the aecidial stage.

COLEOSPORIUM PETASITIS Lév.

Uredospores and teleutospores on *Petasites japonicus* F. Schmidt and *P. palmatus* A. Gray. Dawyck, Peeblesshire, August 1923.

The fungus has not been previously found on these hosts in Britain, but has been recorded on *P. japonicus* in Japan. This appears to be the only record on the Californian species, *P. palmatus*. *Coleosporium Petasitis* has not been found in America and it appears probable that infection of *P. palmatus* has taken place from the fungus on *P. officinalis* which is commonly found in the neighbourhood.

CAEOMA SAXIFRAGARUM DC.

Aecidia on *Saxifraga hypnoides* L. Collected by Greville in June 1822, on Ben Venue, Perthshire.

Pycnidia scattered, rather flat, about ·1 mm. high, ·2 mm. wide. Aecidia scattered on stems and leaves, amphigenous on the latter, surrounded by the ruptured epidermis, ·3–·7 mm. diam.; aecidiospores globose, angular-globose or ovate, densely and minutely verrucose, 17–20 × 13–20 μ.

It is probable that this belongs to some species of *Melampsora* but no species of this genus is recorded on this host by Sydow (*Monog. Ured.* III). Somewhat similar caeomata on *Saxifraga aizoides* and on *S. oppositifolia* are known to belong to *Melampsora reticulatae* and *M. alpina* respectively, and it is probable that the other host of the fungus under consideration is one of the alpine willows. This caeoma has been recorded on *Saxifraga hypnoides* by Dietel (*Verzeichn. sämml. Ured.* 1888, p. 26) in the vicinity of Leipzig.

The specimen is preserved in the Herbarium of the Royal Botanic Garden, Edinburgh.

AECIDIUM PSEUDO-COLUMNARE Kühn.

On *Abies pectinata* Dochfour, near Inverness. Collected by Mr G. Robinson, Oct. 1921.

Five different aecidia have been described on the silver fir. Of these *Melampsorella Caryophyllacearum* Schroet. (*Aecidium*

clatinum Alb. et Schwein.) is easily distinguished on account of the formation of a "witches' broom." In *Calyptospora Goeppertiana* Kühn (*Aecidium columnare* Alb. et Schwein.) the aecidiospores are small (21–30 × 14–18 μ). In *Pucciniastrum pustulatum* Diet. there is a distinct smooth line down the aecidiospore. The aecidiospores of *Melampsorella Symphyti* Bub. and *A. pseudo-columnare* are about similar in size but the latter, according to Kühn (*Hedw.* XXIV, 1885, p. 108) are white and very irregular in shape and size; the warting is asymmetrical and at certain spots, especially towards the end of the spore, may be altogether wanting.

In the Scottish specimens the attacked leaves are scattered sparingly over the shoots and can be easily distinguished by their pale green colour. The aecidia are borne in two rows on the under side of the leaf, the number in each row varying from 3–9. No spermagonia are present. The pseudo-peridia are cylindrical up to 1·5 mm. high and ·4 mm. wide, with irregularly torn opening. The spores are strikingly white, very irregular in form and size, 27–47 × 21–30 μ averaging 35·5 × 25·5 μ. The distribution of warts is irregular but they are not entirely absent over any part of the spore wall.

Ae. pseudo-columnare has apparently been only once previously found in Great Britain—by Munro at Lyme Regis on *Abies pectinata, Nordmanniana, amabilis* and *cephalonica* as recorded by Plowright (*British Uredineae and Ustilagineae*, p. 271). It appears to be very uncommon on the continent. Klebahn (*Zeits. f. Pflanzenkr.* XXVI, 1916, p. 257) has obtained aecidia apparently identical with *Ae. pseudo-columnare* by infecting *A. pectinata* with *Milesina Blechni*.

The specimens were received through the headquarters of the Forestry Commission in Scotland.

Ustilago Bistortarum Körn.

On the leaves of *Polygonum viviparum* L. Meall nan Tarmachan, Perthshire, alt. 3000 ft.

This is the form which produces swollen pustules on the leaves. The spores are 12–16 μ in diam. and are minutely granulated. It therefore does not agree with the var. *glabra* described on this host by Rostrup in Finmark, Norway, which possesses smooth spores 12–13 μ in diam.

Sphacelotheca inflorescentiae Trel.

In the bulbils of *Polygonum viviparum* L. Ben Lui, June 1914, and Ben Ledi, June 1921, Perthshire.

Schellenberg (*Ann. Mycol.* V, 1907, p. 385) has separated this species from *S. Hydropiperis* on account of differences in the structure of the capsule and spores. The mycelium is perennial

in the rootstock and the spore capsule is produced in the lower portion of the bulbil. The columella only extends half-way through the capsule and in this way differs markedly from *S. Hydropiperis*, while the spores are slightly smaller than those of the latter species. The name *S. inflorescentiae* Trel. is prior to *S. Polygoni-vivipari* Schellenberg.

THECAPHORA LATHYRI Kühn.

In the seeds of *Lathyrus pratensis* L. collected by Dr M. Drummond near Edinburgh, Sept. 1923.

Not previously recorded as British but found on the continent. The pods containing infected seeds become dark-coloured slightly earlier than the healthy ones. The spores are powdery and escape on dehiscence of the pods.

I desire to record my thanks to all those who have supplied me with specimens and especially to Mr J. Ramsbottom for help and advice.

OBSERVATIONS ON CAMAROSPORIUM ABIETIS n. sp.

(With Plates III and IV.)

By Malcolm Wilson, D.Sc., Reader in Mycology, University of Edinburgh, and Redvers B. Anderson, B.Sc. (For.).

This fungus was collected March 3rd, 1923, at Arniston, Midlothian, on a solitary tree of *Abies Lowiana*, Murr.

One or two lateral branches were noticed to be destitute of leaves, and on closer examination were found to bear a large number of black fructifications scattered irregularly all over the branchlets. Such branches were low down and well shaded.

The fructifications vary widely in size from ·5 to 1·1 mm. in diameter and at times are closely aggregated, as when they occupy the pulvinar scars or occur within the axils of lateral branches, in the latter case often numbering forty to fifty on an area of 1·5 cm. diameter. Close aggregation of this kind is more noticeable on older branchlets, where the fungus is undoubtedly saprophytic; in the case of young current-year lateral shoots the fructifications are much less numerous and occupy, for the most part, the old leaf scars.

No signs of infection of the main trunk are seen, nor do the fructifications occur close to it.

The youngest fructifications found had already broken through the outer layers of the bark, in the majority of cases one only to each such ruptured area, but in one or two instances a number occurred close together and seemed to arise from a common stroma. When collected they were sooty black in colour, more

or less coriaceous in texture and only rarely shiny; such is their normal dry condition, but in moist weather they become mucilaginous and as a result have a glossy sheen.

The young fructification seen in section (Plate III, fig. 1) consists of a compact mass of hyphae breaking early through the epidermis of the host. It is shortly cylindrical in shape with a slightly flattened expanded base in contact with the outermost compressed cortical tissues. The main portion of this compacted pseudoparenchyma is pale smoky-brown in colour, but in the upper part of the fructification this merges into a distinct wall some 30 to 40 μ thick composed of hyphae closely interwoven, with thick dark-brown walls and numerous cross septa. In the lower part the wall gradually thins out and is no longer distinguishable at the base, where the whole of the pseudoparenchyma is of a similar character throughout. In this basal tissue, and also in the central area, the hyphal cavities are distinct. In the lowermost part no definite arrangement of hyphae is visible, in the uppermost they tend to become longitudinally arranged and later bear the young spores at their apices.

At first, spore formation is limited to a crescent-shaped area some 40 to 50 μ in depth, situated below the apical portion of the wall and separated from it by a thin layer of pseudoparenchyma which never forms spores. These when first formed are spindle-shaped, one-celled, hyaline and contain a few large oil-globules of a pale olive colour (Plate IV, fig. 5, B). Later the oil-globules break up and separate cross walls are developed one near each end of the cell (fig. 6); and soon five to ten cross walls are formed. These at first are colourless but soon darken, gradually taking on a brown colour. A few longitudinally running walls are then developed, these being characteristically oblique or curved and rarely more numerous than three per spore (Plate IV, fig. 5, C and D). The walls still further darken, and as the oil-globules retain their original colour they show up conspicuously in the cell at this stage.

As the spores mature they become freed by the mucilaginous degeneration of the sporophores and a fresh layer of spores arises below them, these being set free in a similar manner (Plate III, fig. 2). The level of spore-formation thus spreads progressively downwards until only a small area at the base of the fructification remains to represent the original compact mass (Plate III, fig. 3, B).

The wall of the mature spore is bronzy-brown in colour and possesses a thin outer layer which is darker in tint than the remainder. The spores measure on an average 30 μ in length by 12 μ in breadth, the maximum and minimum lengths and

breadths being 21–60 $\mu \times$ 10–16 μ respectively. They rarely possess more than two longitudinal divisions in any one transverse stratum, and each cell contains one or two oil-drops embedded in the pale green contents. The spore-walls both internally and externally are free from corrugations and rugosities of any kind and have rounded corners and are comparatively thick relatively to the size of the spore.

Young spores set free by crushing a fructification are generally provided with a sporophore of about their own length, which usually consists of two cells (Plate IV, fig. 5, A). When such spores are put up in hanging drop cultures the sporophore gradually undergoes mucilaginous degeneration and has entirely disappeared before germination takes place (Plate IV, fig. 10, A). In fact the process which would normally take place within the fructification is here continued after the liberation of the immature spores. Stalked immature spores (Plate IV, fig. 5, A) can be readily distinguished from germinating spores with a single short germ-tube (Plate IV, fig. 9, A) by the fact that the latter never possess a cross wall close to the spore whereas the former always show the cross septum separating spore and sporophore.

Simultaneously with the gradual progression downwards of the spore-bearing layer, degeneration occurs in other parts of the fructification. The mass of pale-coloured pseudoparenchyma already referred to, which is found between the first formed spores and the upper part of the wall, breaks down to a greater or less degree, giving rise to a thin pale brown mucilage, which ultimately escapes with the spores. The wall itself also becomes mucilaginous; at a comparatively early stage, when only a small number of spores have been produced it can be seen that the apical portion has already become paler in colour (Plate III, fig. 1), this being the first indication of the process which will ultimately result in the disappearance of the wall. Stages between this and the complete mucilaginisation of this part of the wall were not seen owing to the fact that at this period the latter is so easily ruptured. There is no doubt however that the process continues and the larger fructification seen in Plate III, fig. 4 probably shows its completion. In this case a portion of the upper part of the wall has completely disappeared, but few if any of the spores have escaped. It is possible however that this fructification has been ruptured in section cutting.

The degeneration spreads to the lateral portions of the wall and these are gradually disintegrated from above downwards. As already described spore formation precedes mucilaginisation of the wall and this initial advantage is retained throughout. At any stage, therefore, the side walls project above the level at which spore formation is taking place in the fructification.

The final stage is shown in Plate III, fig. 3, in which the only remaining part of the wall forms a shallow cup which partly encloses the mass of ripe spores which are held together by mucilage.

In order to verify the assumption that the spores escape in wet weather with the mucilage derived from the fructification, the following experiment was carried out. A fructification showing a shiny apex was carefully isolated and the bark on which it was borne trimmed close up to its base. It was now placed on its side close to and above a perfectly clean slide. The fructification was not allowed to touch the slide, but an extremely fine jet of water was directed on to it and the water passing over it collected on the slide. This water, on examination, was found to contain mature spores and a very thin mucilage surrounding numerous oil-globules and hyphal remnants, etc. (Plate IV, fig. 7). The latter may be divided roughly into two groups the components of both of which show advanced degeneration: the elongated portions derived from the sporophores, and the rounded ring-like structures derived from the wall. The oil-drops present were probably previously contained both in the sporophores and in the hyphae forming the wall. The mucilage stains readily with methylene blue but does not take up corallin soda. It is noteworthy that the great majority of the spores contained in it are in the earliest stages of germination (fig. 7, c) as shown by the presence of a light coloured area at the lower end of the spore on the right (see below).

Allescher (1) and Saccardo (3) refer to the presence of a definite ostiole in certain species of *Camarosporium* and in others to its complete absence. Allescher (p. 277) describes *Camarosporium varium* as possessing "unscheinbarer, glatter, glänzender Mündungspapille" and *C. Karstenii* as "mündungslos" and of *C. Visci* Saccardo (III, p. 463) remarks "ostiolis papillatis, demum distincte perforatis." These statements may indicate that there is considerable variation within the genus in this respect, but it is possible that they are the result of incomplete investigation of species similar in their dehiscence to the one described here.

In order to observe the remaining sequence of events in the life-history of this fungus it is necessary to study the germination of the spores and to isolate the mycelium produced by them in pure culture. For this purpose various liquid media were tried, but the only one which proved successful was an extract of *Abies Lowiana* made by boiling the shoots for some time in water. This extract, with the addition of agar, was found to form a satisfactory medium for the further growth of the mycelium. The mature liberated spores germinate freely in the extract and form a germ-tube at one or both ends. The end

from which the germ-tube is about to arise first becomes pale coloured (Plate IV, fig. 10, A) and the terminal cell begins to enlarge and soon projects slightly. At this stage the contents of this cell and the wall are almost similar in colour and in consequence the outline of the cavity can only be seen with difficulty. Soon a small papilla-like outgrowth appears piercing the outer dark-coloured portion of the wall (Plate IV, fig. 8, A and B). This outgrowth which arises from the inner portion of the spore wall is also pale in colour; apparently its passage through the outermost dark layer is the result partly of the wall becoming mucilaginous and partly of the rupture of the portion of the outer layer lying immediately over it. In the early stages it is merely a thickening of the wall but as it increases in size a definite cavity appears which is connected by a narrow channel with the cavity of the cell from the centre of whose wall the tube has originally arisen (Plate IV, fig. 8, C). At this stage the germ-tube is generally as wide as the breadth of the end of the spore from which it has arisen, but in one or two cases it appeared to be constricted as if the original perforation of the outer layer had been insufficiently large to allow the tube to attain its full size (Plate IV, fig. 8, C). The outermost layer of the wall is always visible as a sort of collar round the base of the germ-tube, its limit being sharply defined and having somewhat the appearance of a cross-septum. Later the germ-tube is thin-walled and hyaline with a number of oil-globules irregularly distributed throughout the contents; the basal portion is usually swollen and possesses a few transverse septa (Plate IV, fig. 10, B and C).

The mycelium formed by the germinating spores remains hyaline for a considerable period, being a translucent, very pale sea-green; it branches but rarely. After about a week's growth, it gradually assumes a brown colour and a floccose woolly appearance, and the hyphae attain a breadth of about 4 μ. It is then very similar to the mycelium found in infected host tissues where it is very conspicuous by reason of its colour and size. The growing points of the mycelium are always slightly swollen, their apices always being rounded and smooth. After about a fortnight's growth in the liquid culture the mycelium was found on examination to bear spores at the ends of the ordinary hyphae quite apart from any fructification. Such spores (Plate IV, fig. 12, A and C) are similar in most respects to those found in the fructifications, though some are rather bent and curved in form (Plate IV, fig. 12, B). Fig. 11 shows early stages in the formation of these spores.

Very similar results are obtained in the case of the cultures grown on the extract in agar; the mycelium formed is identical with that already described and bears spores at the ends of

ordinary hyphae in much the same way. In this culture medium fructifications are produced which bear spores similar to those typical of the species.

On reference to Plate III, fig. 3 it will be noticed that there is a mass of pseudoparenchyma at the base of the fructification, undifferentiated laterally, which is not utilised in spore formation; this opens up the question whether or not this pseudoparenchyma is to be considered as a stroma.

Allescher (1) and Saccardo (3) both describe the genus *Camarosporium* as non-stromatic but both make mention of several species in which a definite stroma is present, *e.g.* Allescher (p. 281) with regard to *C. fissum* states: "Fruchtgehäuse...von pseudoparenchymatischem, lederartig-weichem Gewebe,.... mit der Basis einer dunkelbraunen, unter der Rinde sich weit verbreiten Unterlage aufsitzend, welch letztere auch zwischen den nicht zusammenfliessenden Fruchtgehäusen ein weiches, netzartiges Geflecht bildet," and Saccardo with regard to *C. Visci* (p. 463) says "Peritheciis liberis, caespitosis, in stromate spurio dense dispositis, majusculis," and again with respect to *C. Berkeleyanum* (p. 464): "Peritheciis caespitosis....stromate corticali effuso atro maculaeformi insidentibus." Potebnia (2) also in his description of *C. Elaeagni* states that "die benachbarten Fruchtgehäuse sind manchmal mit stromaartigem, sich verflechtendem Mycelium verbunden."

Judging from the foregoing descriptions and those of several other species it is evident that there is considerable variation in the structure of the fructification. An examination was therefore made of nine species of *Camarosporium* and the extent of the stroma-like base investigated. These species could be roughly grouped as follows:

(1) Those in which the fructifications arise from hyphae which retain their individuality, are few in number and loosely aggregated. Three species were included here of which *C. aequivocum* (Pass.) Sacc. may be taken as an example.

(2) Those in which the fructifications arise from a layer of more closely compacted hyphae. Only *C. Laburni* Sacc. is included here.

(3) Those possessing a definite cushion-like layer of closely compacted hyphae on which more than one fructification frequently arises. Five species are placed here of which *C. Coronillae* var. *Coluteae* Sacc. may be taken as an example. The species at present under investigation would also be included in this group.

Amongst the species of *Camarosporium*, therefore, there is evidently a transition from those in which there is no sign of any stroma-like base to those which would commonly be described as definitely stromatic. If, however, a definite stroma is

considered to be present in these latter species the question arises whether they are rightly placed in the genus *Camarosporium*, which, as has already been pointed out, is non-stromatic. The genus *Dichomera* has similar spore characters but possesses numerous fructifications embedded in a stroma which is described as resembling that of *Dothidea*.

The facts that a species of *Camarosporium* has been given the name *C. dichomeroides* and that another species at first included in *Dichomera* has now been placed in *Camarosporium*, may be taken to show that there is considerable resemblance between the two genera. In this connection Potebnia's(2) remarks are of interest. The fungus he investigated is definitely stromatic, but since it does not possess a number of fructifications embedded in the stroma he distinguishes it from *Dichomera Elaeagni* which had already been described by Karsten, and made it a new species which he named *Camarosporium Elaeagni*. It is thus clear that the genus *Dichomera* cannot be distinguished from the genus *Camarosporium* by the mere possession of a stroma; the distinguishing feature is that the former genus possesses a number of fructifications on the stroma whereas the genus *Camarosporium* does not.

The species under investigation must therefore be assigned to *Camarosporium* in spite of the fact that it possesses a stroma and, since it appears to differ clearly from any fungus hitherto described, we propose to describe it as a new species under the name of *Camarosporium Abietis* *. It is clearly distinct from the few species which have already been described on conifers.

There are few, if any, parasitic species of *Camarosporium* recorded and since none of these occurs on conifers it would be of interest should *C. Abietis* prove to be parasitic. In far the greater number of instances the fungus was found growing upon dead tissue either in the nature of dead bark and cortical cells or on completely dead lateral branches. In one or two instances, however, it was found infecting current-year shoots, destitute of leaves, which were terminal to still living leaf-bearing twigs. The question therefore naturally arises as to whether defoliation follows infection of the shoot, or infection follows the death of the shoot, the latter being more or less accurately recorded by leaf-fall.

The needles of *Abies Lowiana* seem to remain on the tree for some three or four years, or at any rate this figure holds

* Camarosporium Abietis, n. sp.

Peritheciis erumpentibus et prominentibus, gregariis, nigris, laevibus, globoso-hemisphaericis vel breve cylindricis, ·5–1 mm. diam., ostiolo nullo; sporidiis brunneis, dilute coloratis, muriformibus, non constrictis, 30–60 × 10–17 μ; septis transversis 2–10 (plerumque 5–8), septis longitudinalibus circ. 3; sporophoris bacillaribus, articulatis, hyalinis, sporulam subaequantibus.

Hab.: Scotia, prope Edinburgh; in ramis *Abietis Lowianae*.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

5

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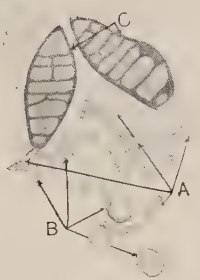

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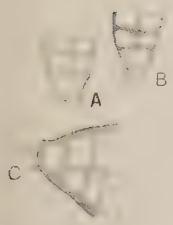

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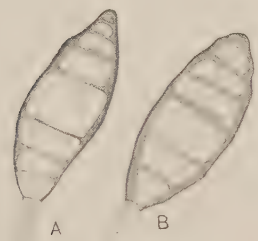

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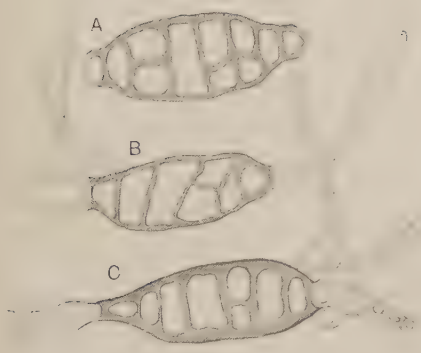

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good for the lower shaded branches. If, therefore, complete defoliation occurs prior to the third year it is either the result of disease or death of the tissues from some other cause.

In an endeavour to ascertain whether the mycelium of the fungus penetrated living host tissues, it was decided to section living twigs which were bearing leaves on all but the current year terminal shoots, the latter portions being clearly infected and evidently dead. Examination of the sections showed that the dead portions were infected and that hyphae could be traced close up to the junction of completely dead and still living tissue, but no penetration of still active living cells was found to take place, and infection of the cells, therefore, appears to be possible only after they have died.

Webster(4) maintains that *Abies Lowiana* has proved exceedingly hardy in Britain and one would suppose, therefore, that it should be free from frosting. The current year has seen some severe late and early frosts, notably those of June and September, and it would be unwise to say that these have had nothing to do with the killing of young current-year wood. Moreover, many of the needles of the tree in question bore the browned tips which are more or less characteristic of frosting and many still uninfected shoots were found minus their bud-apices as if the latter had been nipped. In the meantime, therefore, until infection experiments, which are being carried out, give a definite result one way or another, it may be taken that the fungus is saprophytic.

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EXPLANATION OF PLATES III AND IV.

Fig. 1. A young fructification showing paler area in centre of apex. × 40.
Fig. 2. Spore-forming layer showing *a.* young, *b.* mature spores, *c.* sporophores becoming mucilaginous. × 135.
Fig. 3. A mature fructification showing *a.* mature spores, *b.* residual non-spore-forming pseudoparenchyma, *c.* basal stroma-like area. × 50.
Fig. 4. Two mature fructifications on a common stroma. × 50.
Fig. 5. Mature spores and their sporophores. *a.* a rather uncommon rounded type, *b.* immature one-celled spore containing oil-globules, *c.* and *d.* typical spindle-shaped spores. × 312.
Fig. 6. Immature spore with the two first formed cross walls. × 312.
Fig. 7. Spores in mucilage after escape from the fructification. *a.* elongated portions, *b.* ring-like portions, *c.* spores. × 225.
Fig. 8. Early stages in germination. *a.* papilla-like outgrowth appearing, *b.* outgrowth enlarging, *c.* a very young germ-tube. × 312.
Fig. 9. Germinating spores after 24 hours in culture solution. × 312.
Fig. 10. Germinating spores after 72 hours. *a.* spore about to germinate at both ends, *b.* showing a median cell germinating, *c.* end cells germinating. × 312.
Fig. 11. Mycelium with spore-forming apices. × 240.
Fig. 12. Mycelium bearing spores. *a.* and *c.* mature, *b.* immature. × 240.

A RHIZOCTONIA CAUSING ROOT DISEASE IN UGANDA.

(With Plates V and VI.)

By W. Small, M.B.E., Ph.D., F.L.S., Biological Laboratory, Department of Agriculture, Kampala, Uganda.

Introduction.

In Uganda the silky oak (*Grevillea robusta* A. Gunn) has been planted to a large extent as an ornamental tree in gardens and elsewhere and as a shade-tree and wind-break on coffee estates. There is, therefore, a certain amount of interest in its diseases and pests, and the death of a silky oak is sure of notice. In recent years, many trees have died in gardens, on roadsides, and, more lately, among coffee, and it has been customary for the layman to assume the losses to be due to the work of white-ants (*Termes bellicosus* L.). Clear evidence of the presence of the insects is seldom lacking; in fact, they may demolish the underground parts of a silky oak so rapidly that the first sign of trouble is the breaking of the tree at ground-level while the foliage is, to a casual glance, normal in appearance, and so thoroughly that they obliterate almost entirely traces of other harmful agents that may be present and leave only evidence of their own work. The attacks of the termites, however, can be shown to be confined to trees that have already been weakened by, or are dying of, root disease, and the insects are therefore to be regarded as secondary agents in the loss incurred. On occasion, diseased trees escape the attention of the insects, and there is then no difficulty in allocating to a parasitic fungus the real responsibility for deterioration and loss.

Only one root disease of *Grevillea*, the subject of part of the present paper, is known in Uganda. It occurs on trees up to five, six or more years of age, and it has been shown to be caused by a species of *Rhizoctonia*. The writer is not aware of any record of a similar fungus on silky oak, and the fungi associated with root disease of the tree in other parts of the world, particularly Ceylon and the East,—*Ustulina zonata* Lév., *Rosellinia arcuata* Petch, *Ganoderma applanatum* (Pers.) Pat., and *Ganoderma australe* (Fr.) Pat.,—have not been encountered in Uganda. Up to the present, the *Rhizoctonia* has not spread from its host to adjoining trees of *Coffea arabica* shaded or protected by *Grevillea*, although the respective root-systems are in close association with each other. It will be unfortunate if the *Rhizoctonia* attacks Arabian coffee, an important crop that so far has been remarkably free from root diseases. Single

occurrences of the *Rhizoctonia* on tea and arnatto (*Bixa Orellana* L.) are discussed later. The fungus has also attacked *Casuarina equisetifolia* and *Coffea robusta*; which latter is grown on certain estates in addition to *C. arabica*. Attention may be drawn to the fact that the *Rhizoctonia* has occurred only on introduced *Coffea robusta* (originally from Java), and that none of its five hosts is indigenous to Uganda. It may be mentioned that this is the first record of a species of *Rhizoctonia* in this part of Africa. The present species is evidently widespread in Uganda, for cases of its parasitism have been noted in districts far-removed from each other.

Symptoms of the Root Disease of Grevillea Robusta.

The browning and wilting of part of the foliage of a tree is the first symptom of attack and consequent disease, but it frequently happens that blackening of areas of the trunk followed by exudations of a resinous or gummy substance from the trunk and larger branches, if the tree is an older one, is the first cause of attention being drawn to its abnormal condition. Subsequently, certain upper branches or shoots may become leafless, and a "stag-horn" condition may be apparent. It has been customary to refer to this effect of the root disease as "die-back." *Nectria flocculenta* v. Hoehn. and a species of *Phoma* may be found on the dead and dying twigs, but these fungi have been shown to be merely saprophytic. In addition to the cracks in the trunk, others appear at the collar of the tree, which also may give rise to streams of gum, and lead eventually to the scaling of the bark. At this time, a cut into the bark and cortical tissues discloses a certain amount of discoloration which microscopic examination shows to be accompanied by internal accumulations of gum, and an examination of the cambial tissues shows that they have entirely broken down. No hyphae have been found in association with the gum in the stem more than a few inches above the collar, but numerous and characteristic oil-globules exude from sections of all the degenerating tissues. In young diseased trees, suckers often sprout from the base of the trunk, and cases are known in which a sucker has grown to be as large as the original stem of the tree before death ensued. It is likely, therefore, that the progress of the disease is slow, but there is, unfortunately, no doubt about its eventual result.

When the underground parts of a diseased tree are exposed by excavation, symptoms of the root-disease may not obtrude themselves at once on the investigator. In fact, if the case of disease is of short standing, the roots of the tree, except for a slight, superficial blackening of the smaller ones, may appear

to be in a normal condition, and only a histological examination of the internal tissues will prove the presence of the *Rhizoctonia*. In older cases, again, but only in the larger roots, careful washing may reveal on the surface of the bark thin black sheets of tissue which are often slightly raised or ruptured, and which are in evident connection with the internal mycelium of the fungus. Their position and the ease with which they can be detached may enable them to function as rhizomorphs, for it has been shown by experiment that a rapid and profuse growth of mycelium can be induced from a small piece of black sheet by placing it in a suitable medium, and it is therefore probable that they play a part in the dissemination of the *Rhizoctonia* under natural conditions. They, however, are not of regular occurrence in an exposed position like the surface of a root. Owing to the dry condition of the wood, the roots are usually firm and brittle, and a closer examination of the bark and of the surface of the wood after removal of the external tissues may disclose the presence of numerous small black sclerotia in the wood, cortex and bark. The sclerotia may be numerous enough to show through the bark, and cause a distinct blackening of the surface of the roots. Sheets or crusts of black tissue also occur in the roots and pursue an irregular course and thus appear in a rough longitudinal section as thin wavy lines which in places double upon themselves and form "islands." They are seen to most advantage in the wood, and their presence is sometimes denoted by a distinct yellowing of the tissues, a discoloration which is more or less bounded by the extent of the lines. The black sheets or crusts are not consistently present throughout the diseased tissues, but they can be found at times in the bark and cortex as well as in the wood. In the former they are connected with and give rise to the external sheets of black tissue mentioned above; in the latter they do not define necessarily the limits of penetration of the hyphae. The small black sclerotia, on the other hand, are to be found in advanced cases of infection throughout the tissues of the roots and extending into the wood of the collar of the tree.

The Rhizoctonia in the Tissues of Grevillea robusta.

(a) *Hyphae.*

The hyphae of the fungus occur in quantity throughout all the tissues of the diseased roots. In the wood, they vary from very pale- to dark-brown in colour according to age, are septate, usually granular and with oil-globules, and measure up to 10 μ or more in thickness. They may be irregularly swollen and angled or barrel-shaped, and are often more gnarled

in tracheids than in the parenchyma. In penetrating a cell-wall or pit, a hypha may be constricted during passage and swollen immediately afterwards. Clamp connections are scarce, but are to be found on the larger threads. The basal constrictions of the cells and the position of the first septum of a branch hypha, although known to occur in other forms, are nevertheless characteristic of *Rhizoctonia* mycelium. Chlamydospores occur occasionally in the course of the hyphae. Anastomosis of neighbouring hyphae is frequent, and the branching is free. (Plate V, figs. 1 and 2 show two typical portions of the older mycelium of *Rhizoctonia* in the wood and cortex of a *Grevillea* root, and fig. 3 gives an example of the extent to which the hyphae may fill the cell-cavities of elements of the medullary rays.) A certain amount of choking of the cell-cavities by accumulations of gum always occurs.

(b) *Sclerotial plates.*

The so-called black crusts which are found in affected roots are seen in section to consist of plates of cells which vary in thickness and which extend laterally and irregularly by advancing into and filling up adjacent cell-cavities. The cell-walls are dark-brown in colour and comparatively thick. The cells contain oil-globules and frequently appear to telescope into each other (Plate V, fig. 4). A crust however is seldom of so simple a structure as shown in the figure or of so uniform a thickness. It consists rather of a set of two or more plates of cells more or less parallel connected by short hyphae, and becoming more or less fused together. The black crusts in the wood of the roots of long-standing cases of disease (for example, in those of a tree which was not dug up until four months after death), are frequently found to have coalesced with the sclerotia already present, to form continuous sheets which often take the place of connective tissue and grow upon and over the vascular bundles in the form of a crust; they can be made to grow in this manner in the laboratory by keeping a piece of root with lines and sclerotia in damp sterilized sand. Growth of this nature is easiest along the medullary rays, but it is slow, and the time required for it to cover the exposed surface of a split block of root two inches in length and one inch in diameter is from four to six months.

When the material is bleached and mounted, the surface view of a piece of such a sheet presents a striking appearance. The black tissue is seen to consist of a closely-knit mosaic of dark-brown cells which at first sight and in most cases, since the sheet is invariably more than one cell thick, seem to be triangular in shape and remarkably similar to each other. Individual

hyphae, however, can be distinguished, and they are of the structure shown in Plate V, fig. 5. The cell-constrictions and the positions of the first septa are characteristic, as already mentioned, but the respective appearances differ inasmuch as the hyphae of the solid sheets possess the two typical characteristics in what may be called an exaggerated form. Swollen and triangular-shaped cells in which the basal constrictions are less marked than usual invariably occupy the branching points of the hyphae and give rise to new hyphae by a kind of dichotomy, and anastomosis between adjacent hyphae causes a peculiar hammer-head appearance when the neighbouring cells are not viewed in the same plane. A crust in the wood of a root originates in the modification of hyphal cells which become short and barrel-shaped, develop numerous oil-droplets, darken in colour, and blacken the walls and fill the cavities of adjacent cells by expanding into a sclerotial-like mass. They assume their characteristic appearance early, and so differ at once from the vegetative hyphae which have given rise to them. The nature of the cells points to their being able to pass through a resting period, and support is lent to this view by the fact that mycelial growth is immediate and plentiful from fragments of lines taken from dry pieces of diseased roots which have been lying in the laboratory for over six months. The function of a crust, then, is that of a rhizomorph, or, in view of the nature of the cells, that of a piece of resting tissue capable of giving rise to creeping and active mycelium, the equivalent of a mass of chlamydospores or sclerotia. This function is clearly indicated, and, when considered in conjunction with the structure and nature of the tissue, may justify the substitution of the term "sclerotial plate" for that of "crust." In fact, it is difficult at times to distinguish readily between the structure of a sclerotium exposed by a section and that of a piece of sclerotial plate when cut across. A comparison of the material of an early case of *Rhizoctonia* disease with that of one of long-standing seems to point to the formation of sclerotial plates preceding the production of sclerotia, but, on the other hand, it has been noted that sclerotia are present in tissues from which the plates are absent. The two structures are, therefore, independent of each other, although, as is mentioned later, a sclerotium may arise indirectly from a sclerotial plate.

(c) *Sclerotia.*

The sclerotia are found in great numbers in parts of diseased roots. They may protrude from the bark and be numerous in the cortex. They also occur throughout the wood, but their appearance is most striking when they are seen as a mass of

black dots on the surface of the exposed wood. They appear to be smooth, but under high magnification the smoothness is seen to be modified sometimes by the protruding ends of hyphae which are hyaline or pale-brown and often conical in shape. Their outline is conditioned to a certain extent by the surrounding tissue, but is, for the most part, circular, oval or pear-shaped. The majority of the sclerotia are flattened and closely attached to the substratum; when they are old, they can be readily detached by mechanical means. In the wood they occupy conjunctive tissue spaces, and they also occur on the vascular bundles and along the medullary rays. Their greatest length is about 1 mm. and greatest breadth about ·8 mm., but the endwise coalescence of two adjacent sclerotia may present a dumb-bell shape and an apparently greater length than the figure given. The sclerotia have not been observed to unite to form coriaceous masses.

In the tissues, a sclerotium originates in a short line of brown, thick-walled, barrel-shaped and guttulate cells occurring in the course of a hypha which may or may not be in direct connection with a black line (Plate V, fig. 6). The young sclerotium is comparatively long and narrow (Plate VI, fig. 21) and bounded by the cells of the tissue in which it is formed. In structure, a sclerotium consists of a spongy core of irregularly-shaped, more or less thin-walled parenchymatous cells, the average diameter of which varies from 10 μ in some to 5 μ in others. The sclerotia are of one type only. They are remarkable for their large oil-content and are apparently well-fitted for a resting function. Plate V, fig. 7 shows part of a sclerotium with connected hyphae penetrating the adjacent tissues.

(d) *Hymenophore.*

During the study of the *Grevillea* material, the possible existence of a fruiting or *Corticium* stage of the *Rhizoctonia* was kept in mind, and, after much search, a supposed hymenophore was encountered in small amount on one lot of material and in association with a sclerotial plate. Little is known about it and further study of its peculiar formation is not only desirable but essential to throw light on its true function and significance. Under a lens, the usual appearance of a sclerotial plate in either natural or artificially induced growth is that of a smooth and apparently hard carbonaceous surface, but, in the case of the material under discussion, there is to be noted a minutely pilose appearance which on analysis is found to be due to the presence of basidia-like structures and numerous processes arising from the mycelium of the plate. The processes are simple and finger-like or branched and swollen (Plate V, fig. 8). They measure

only 1–3 μ in length when simple, and are usually hyaline at the tip. Some are slender and others are comparatively stout and clavate in shape. They arise from any part of a hyphal cell or in groups of two or more from cells resembling basidia. No spores have been found in association with them, and their function is therefore obscure, but their arrangement points to the possibility of their being abnormal sterigmata. The supposed sterigmata are short and simple and are borne in twos and fours on rounded hyaline basidia which are themselves cut off from hyphae resembling the vegetative hyphae of the *Rhizoctonia* (Plate V, fig. 9), but there is no extensive development of the latter hyphae to form a special hymenophore. No spores have been seen on the sterigmata.

The supposed hymenophore was found on the surface of the wood of a *Grevillea* root which was still internally moist, and from which no bark had been detached until the material was examined in the laboratory. It is apparently of an imperfect nature, induced, it may be, by a gradual process of abortion, and its present significance in the life-history of an organism which is well-equipped with vegetative means of reproduction and spread may well be of little and diminishing importance. As far as is known, the hymenophore occurs only between the bark and wood of a root which is far from the stage of decay that would liberate the basidiospores of the fungus.

The Grevillea Rhizoctonia in Pure Culture.

Cultures of the *Rhizoctonia* have been obtained from root fragments containing hyphae and from pieces of sclerotial plates and scrapings of the supposed hymenophore tissue, in dealing with which every care has been taken to guard against the presence of contaminating elements. The inocula have been thoroughly sterilised by dipping in alcohol and by subsequent flaming or immersion in a saturated solution of corrosive sublimate in alcohol. In many cases, both treatments have been given to the inocula, and, in consequence, a large proportion of them has been rendered incapable of growth. Despite many attempts, neither rested nor fresh sclerotia have been induced to germinate in culture media or in soil or sand. The fungus grows well on agar media (prune + 15°, oatmeal + 10°) and on sterilised filter paper moistened with sugar-cane decoction. The growth of the fungus renders the solid media dark in colour after a few days and black when the development of sclerotia is well-advanced. In most cases, young hyphae are visible in from 12–24 hours, and in all cases sclerotial formation follows almost at once. The young hyphae are colourless, branched, sparingly septate at first, and swollen at the tips; they appear

on the surface of the medium as small, whitish tufts. After a day or two, the hyphae measure up to 8 μ in diameter. Clamp connections are found on the hyphae when they are a few days old (Plate V, fig. 10), but never on the youngest threads. Plate VI, fig. 11 shows the characteristic branching of 24 hours-old mycelium in which the new branches pursue a course almost parallel to the parent hyphae. The mycelium becomes granular and develops barrel-shaped cells with oil-globules in 48 hours (Plate VI, fig. 12). In three days the cells measure up to 30 μ in length, are granular and contain numerous oil-droplets, while in eight days the mycelium presents the appearance shown in Plate VI, fig. 13. Many of the cells are then swollen and thin-walled (Plate VI, fig. 14), while others are assuming the typical *Rhizoctonia* outline. In several cultures, especially in those derived from fragments of sclerotial plate tissue, the mycelium aggregates itself into dark strands which seem capable of becoming creeping rhizomorphs. The curious cell-formations shown in Plate VI, fig. 15 occur in growth from sclerotial plate and hymenophore fragments after a period of eight days. They are most distinctly seen in filter-paper cultures. The majority of them are terminal in position, and they frequently arise from small thin hyphae. The rounded swollen cells are dark-brown in colour and well supplied with oil-droplets, and the general formation of the mass of cells is irregular. The figure shows several cells in process of segmenting and also the rounding-off that follows division. Individually the cells resemble chlamydospores, and, in the mass, the first stages in the formation of sclerotia. Similar rounded dark cells occur singly or in small groups in the course of the mycelium of certain cultures, but neither their history nor that of the larger cell-formations has been followed further. They presumably perform a resting function, for individual cells of the larger type can be found separated from the general mass when the medium dries up. When a filter-paper culture is allowed to dry and the growth of the fungus is arrested in consequence, chlamydospores are formed in large numbers and at times so abundantly in the course of the hyphae as almost to jostle each other for room. They measure up to 8–10 μ in diameter, and are thick-walled, oily, and darker in colour than the hyphae. They are both terminal and intercalary, and rounded or subpyriform (Plate VI, fig. 16). A few of the darker cells have been noted in a state of division, and it is probable that they would have given rise to the curious cell-masses mentioned above had development been allowed to proceed. Besides the normal chlamydospores, others which differ only in their reduced size can be found in small groups as if budded off from the larger spores. They are

regarded as starved spores, but, in other cases, they seem to be the remains of abortive attempts to form lateral branches of the hyphae. In all probability they would have developed into cell-masses or hyphae if growth had continued. The sclerotia of a drying culture measure only ·38 by ·27 mm. Sclerotia form profusely in solid media and also on the surface of moistened filter-paper cultures. Their development is seen more easily in the case of the latter, and the drawings and notes therefore refer to filter-paper growths, although the process is the same in all media. A sclerotium originates in a small group of hyphal cells which become darker than the adjacent cells in colour, rounded, thick-walled and guttulate, by continued segmentation not only of the original cells but also the laterally-placed units to which the core has given rise. The original cells are soon lost to view, and certain of the peripheral cells grow outwards to form hyphae (Plate VI, figs. 17–20). The whole structure becomes a mass of pseudoparenchyma which expels a large quantity of oil on being crushed under a cover-glass. In the mature sclerotium, the central cells have thinner walls and larger lumina than the peripheral cells. During their growth, the sclerotia can be seen in the medium as dark masses which become black in eight days and mature in about one month. They can then be detached easily from the medium, especially if the latter is in process of drying up. In culture they are of a more regularly round-oval shape than in nature, but some are elongated and narrow while others are almost spherical. An average measurement is ·5 mm. long by ·35 mm. broad, but very many of the sclerotia are smaller and others are larger than this. The mycelium in the body of the medium has not been observed to assume the colour and form of that of the black plates in the tissues of diseased roots, and the sclerotia, like those formed naturally, have refused to give growth of any kind even after a nine months' rest. No *Corticium* stage of the *Rhizoctonia* has been found in any of the cultures.

As already mentioned, the fungus in *Grevillea* tissues can be induced to grow by keeping pieces of infected roots in damp sand. The exposed surfaces of the pieces become covered with mycelium which eventually assumes the black sheet or crust form, and sclerotia develop in great numbers independently or in direct connection with the sclerotial-plate tissue. In such cases, the sclerotia are larger and more swollen than those developed naturally, and the black sheet assumes the form of a detachable crust. Although it might be expected to appear, no *Corticium* stage of the *Rhizoctonia* has been found in these root-fragment cultures.

The Rhizoctonia on Tea and Arnatto.

Until the discovery of the *Rhizoctonia* on tea, the only root disease of that host recorded in Uganda had been a rot caused by *Armillaria mellea* Fr. Since it happens that the single affected tea plant has been growing in close proximity to a diseased *Grevillea robusta* tree, it is concluded that infection has been brought about by contact between the hosts of the fungus. In any case, the fact remains that tea is susceptible to the *Rhizoctonia* root disease, though on a smaller scale than *Grevillea*, and this remark applies also to the undermentioned third host of the fungus, the arnatto (*Bixa Orellana* L.).

No external black plates of tissue have been found on the tea roots, and the sclerotia are few in number and concealed in the bark and wood. The wood of affected roots is dry and hard and so permeated in parts by the hyphae of the *Rhizoctonia* that it is darkened in streaks, while the black lines or sclerotial plates are of finer texture and of sparser occurrence than in *Grevillea*. Their structure, however, is similar to that already found in *Grevillea*, and the same spongy extensions filling adjacent cell cavities are apparent. The internal mycelium, again, is not of so consistently dark a colour as that in *Grevillea*. The hyphae ramify in all directions, the larger and older passing longitudinally down the vessels and being at times sufficiently numerous to form a tangled mass, while the younger and more hyaline threads, branching from the older invariably at right angles to them, pass freely through obstructing cell walls. The hyphae vary from 2 to 10 μ in breadth, and their largest cells measure up to 35 μ in length. The sclerotia differ from those of *Grevillea* in being less numerous and smaller in size, and, owing to their being shut up in the tissues, in their ill-defined and less distinct outline.

The fungus has been grown in pure culture in the media previously used and found to behave in the same way as that from *Grevillea*. No fruiting stage has been encountered either in nature or in culture.

At a later period and in a different locality, a tree of *Bixa Orellana* growing beside a dying *Grevillea* tree was observed to wilt, and both specimens were dug up for examination. The *Grevillea* being a typical case of *Rhizoctonia* root disease, it is not surprising that the *Bixa* has proved to be a second example of a host infected by contact. The wood of its roots is dry and brittle and stained in the manner of the tea roots. The external indications of the *Rhizoctonia* consist in the presence of sclerotia on the bark of the smaller roots. Being rounded on their free sides, the sclerotia protrude from their substratum. They correspond in size to those of the *Grevillea* fungus and they contain the same comparatively large quantities

of oil. They occur also on the surface of the wood, and in that position are indistinguishable from those of *Grevillea*. The hyphae in the smaller roots are typically *Rhizoctonia*-like, and permeate the host tissues very thoroughly. Clamp-connections and chlamydospores, neither of which have been seen in tea root sections, are common. Black sclerotial plates occur only in the driest and presumably earliest-infected roots, but hyphae are plentiful in the wood of the collar of the tree. The plates are of the usual structure, and they give off branch hyphae which leave the parent mycelium at the usual right angle and penetrate the surrounding tissues. On the larger roots, the mycelium of the fungus is most plentiful in and near the cambial tissues, in which position it forms thin continuous sheets resembling the black plates and also the growths of the *Grevillea* fungus on filter paper. These sheets cling closely to the inside of the detached bark. In all three cases, *Grevillea*, tea, and *Bixa*, the hyphae of the *Rhizoctonia* have been observed to make little use of pits in their passage through the tissues, but penetrate, apparently without difficulty and doubtless by the action of one or more enzymes, all obstructing cell-walls. The cell-cavities throughout the wood of diseased roots of tea and *Bixa* are frequently filled with gum, a condition recalling that found in the roots of *Grevillea*.

The *Bixa* fungus has been isolated from root fragments and grown in the same media as the tea and *Grevillea* forms. After thirty-six hours, the young hyaline mycelium shows the typical form and method of branching. The hyphae then measure up to 8 μ in diameter, and are often aggregated into strands of from two to six or eight threads. Further developments follow the lines already described.

The Rhizoctonia on Coffea robusta and Casuarina equisetifolia.

The *Rhizoctonia* was subsequently discovered on *Coffea robusta* and *Casuarina equisetifolia*. These cases differ from those of the tea and arnatto inasmuch as none of the affected plants—and examples of the root diseases of each have been obtained from different localities—had been growing in close proximity to either healthy or diseased *Grevillea robusta*. The infections are not only independent of *Grevillea* but also of each other, and they establish a suspicion that the *Rhizoctonia* is unlikely to be confined to the first host on which it was found or to the tea and arnatto to which it has seemed to spread. All the new cases have occurred on European coffee estates which are in good order. The *Coffea robusta* is planted in the usual way in plots,

and the *Casuarina* trees form, in one case, part of a wind-break and, in another, part of an ornamental garden.

In the *Coffea robusta* disease, death had apparently been sudden, for each affected tree found in the field was standing with all its leaves in position. The smallest rootlets are dry and shrunken, and the bark of the smaller roots cracks and peels off readily to expose numerous black, flattened or rounded sclerotia embedded in the cortical tissues. The wood of the roots is hard and brittle, as in the previous cases of the disease, and often discoloured by the presence of mycelium, and its surface is dotted in certain parts by sclerotia. Black sclerotial plates are present. The sclerotia occur also throughout the wood, but they are most frequent in the cortex. In the latter position, they are often so irregularly-shaped and numerous that they form an almost continuous black sheet underlying the bark, which recalls a similar appearance in *Grevillea robusta* roots. The average size of the sclerotia is ·45 by ·3 mm., and they are, in general, and apart from their smaller size, indistinguishable from those of the *Grevillea*, tea or arnatto fungus. In the collar of an affected tree, sclerotia can be found in the cortex of the first few inches of stem above soil level; the accompanying mycelium is confined to the cortical and outer tissues of the wood. The hyphae of the fungus are similar in colour, shape and measurements to those of tea and arnatto. The larger pass down the main tracheids in the wood, and give off branches at the usual right angle. The hyphae are most plentiful, however, in the cortical tissues where they frequently give rise to extended plates of flattened, typically *Rhizoctonia*-like mycelium resembling that of the sclerotial plates of *Grevillea*. In this mycelium, the swollen lateral hyphae are connected at times to the parent hyphae by extremely narrow necks, and there is enough globular swelling among the cells to recall the curious cell-formations found in *Grevillea* cultures. Some of the cell-walls of these hyphae possess spiny processes similar to those described from the *Grevillea* hymenophore, but no further likeness to the *Corticium*-like stage of the fungus can be noted. Sclerotia in all stages of development are common in the cortex of some of the roots, and one of them, in which the outline of the young sclerotium is conditioned by the surrounding tissues, is shown in Plate VI, fig. 21.

With regard to the fungus on *Casuarina*, there is nothing to add to the details given for the other hosts. Mycelium and sclerotia, the latter measuring up to ·7 by ·4 mm. and, on the whole, more irregular in shape than those of *Grevillea*, are found in abundance on the stem of the tree above soil level. Black plates are also present in the wood of the roots.

Infection Experiments.

The pathogenicity of the *Rhizoctonia* has been tested only with material from *Grevillea robusta* and only with respect to *Coffea arabica*. The work has been necessary in order to throw light on a point of great practical importance to those planters who have instituted *Grevillea* wind-breaks and shade for their coffee, and it can be said that the results of the experiments have supported what has been evident in the field, viz., that the *Rhizoctonia* which has had abundant opportunity to pass under natural conditions from *Grevillea* to *Coffea arabica* has not yet attacked the latter host. It is necessary to distinguish here between *Coffea arabica*, the staple crop on the majority of European estates, and *Coffea robusta* which is planted in comparatively small, but increasing, amount, and to remember that only the latter species is known to be susceptible to *Rhizoctonia* root disease.

Only healthy coffee plants in pots have been employed in the experiments. The inoculum has consisted of small blocks of culture medium containing active mycelium and sclerotia. The fungus has been brought into contact with its intended host by wrapping the inoculum around both wounded and unwounded lateral and tap-roots and also by inserting it under the bark of the stem just below ground level. Sclerotia, both dried and freshly taken from cultures, have been placed among the roots of other plants, and pieces of *Grevillea* root, bark and cortex containing black plates and sclerotia have been wrapped around roots and also the collars of further plants. Although the fungus has been allowed over eight months during which to force an entrance into and obtain a footing in the tissues of the experimental plants, no positive results have accrued, and an examination of certain of the plants has shown their roots to be unaffected by the treatment accorded them. It is to be hoped that the present apparent immunity of *Coffea arabica* will continue unabated, for, were the diseased *Grevillea* trees to cause the death of *Coffea arabica* trees in contact with them, the loss would be great enough to bring about a very serious state of affairs on certain estates.

The Systematic Position of the Fungus.

The systematic position of the fungus described in this paper is somewhat doubtful. The presence of clamp-connections points to its being a Basidiomycete, and the discovery of the bodies presumed to be abortive basidia lends support to this view. On the other hand, the absence of a fully-developed perfect stage makes it impossible to refer the fungus to its correct position, and the only course open in the meantime is that of

placing it in one of the form-genera which have been created for the reception of sterile mycelia.

The two form-genera which come into consideration are *Rhizoctonia* and *Sclerotium*, both of which as at present constituted obviously contain heterogeneous elements and both of which would disappear entirely with the discovery of the perfect stages of their various species. In deciding the question of a place for the present species, weight has been placed on the structural characters, including the clamp-connections and the probable connection of the species with a lower Basidiomycete (in which point it would agree with *Rhizoctonia Solani*), rather than on the absence of external mycelium, a character which is appropriate to the genus *Sclerotium*. It is proposed, therefore, to refer the present form to *Rhizoctonia* and to institute a new species. The specific name, *lamellifera*, refers directly to the frequent presence and constant character of the sheets of modified hyphae which have been called "sclerotial plates" in this paper, and its use seems the more appropriate inasmuch as no record of similar structures has been found in the literature of parasitic species of *Rhizoctonia* except, perhaps, in the account of *Rh. Strobi* E. Scholz on *Pinus Strobus* *, a species which was described on a well-grown tree.

Rh. lamellifera sp. nov.

Hyphis lignum et corticem profunde penetrantibus, filiformibus, crassioribus, ramosis, anastomosantibus, demum fuscescentibus, septatis, non superficialibus, interdum in membranam castaneam coalitis; membranis e cellulis contextis, irregularibus, angulatis compositis, plerumque in ligno corticeque immersis, vel rarius externis, subinde corpora basidiis et sterigmatibus similiter gerentibus, Sclerotiis numerosis, fere levibus, globosis vel pyriformibus, saepe complanatis, haud erumpentibus, ad 1 mm. longis, ·8 mm. latis, e cellulis pseudo-parenchymatis, irregularibus, 5–10 μ diam. compositis, Sclerotiis guttulas oleosas copiosissimas includentibus. *Hab.* in ligno et cortice radicum viventium *Grevilleae robustae* (typus), *Theae*, *Bixae Orellanae*, *Coffeae robustae*, *Casuarinae equisetifoliae* cultae quas necat.

Summary.

1. A new species of *Rhizoctonia* has been found to attack *Grevillea robusta*, and its morphology and behaviour in culture are described. Its distinctive characters are the presence of sclerotial plates and sclerotia.

2. The connection between the plates and the sclerotia has been established in cultures started from the plates. Owing to

* Verhandl. zool.-bot. Gesellschaft, Wien, xlvii, p. 541, 1897.

failure to secure germination of the sclerotia, sclerotial plates have not been obtained in culture from a single sclerotium.

3. At a later date, a fungus agreeing in morphological and cultural characters was encountered on tea and *Bixa Orellana*.

4. What is considered the same fungus was afterwards discovered on *Coffea robusta* and *Casuarina equisetifolia*, but has not yet been isolated from either.

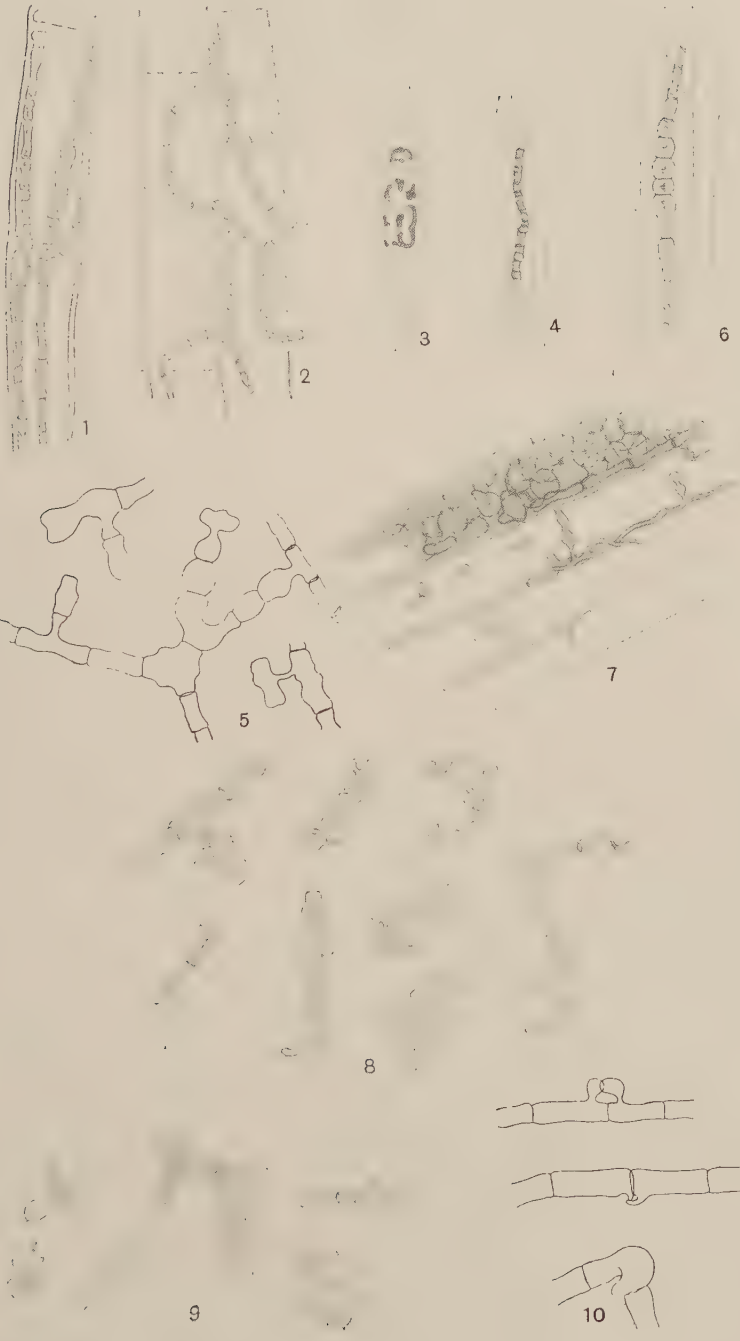
5. To date, the inoculation experiments attempted have dealt only with the important question of the susceptibility or immunity of *Coffea arabica* to the *Rhizoctonia*. The results have been entirely negative.

The writer wishes to express his thanks for help in the systematic portion of this paper to Miss Wakefield of the Kew Herbarium and to Mr E. W. Mason of the Imperial Bureau of Mycology, and his indebtedness to the Director of the Bureau for laboratory facilities.

EXPLANATION OF PLATES V AND VI

Figs.

1–2. Hyphae in wood and cortex of a *Grevillea* root. ×250.
3. Hyphae in a medullary ray cell. ×250.
4. Portion of a sclerotial plate in *Grevillea* root. ×150.
5. Hyphae of a sclerotial plate. ×400.
6. First stage in sclerotial-formation in *Grevillea* tissues. ×250.
7. Hyphae and part of a mature sclerotium in wood of a *Grevillea* root. ×250.
8. Mycelial processes. ×350.
9. Basidia and sterigmata. ×350.
10. Clamp-connections on hyphae in culture. ×300.
11–12. Young mycelium from cultures. ×300.
13–14. Eight-day old mycelium from a culture. ×150.
15. Cell-formations in culture. ×250.
16. Chlamydospore-formation in a drying culture. ×250.
17–20. Successive stages in sclerotial-formation in culture. ×250.
21. Young sclerotium in root of *Coffea robusta*. ×100.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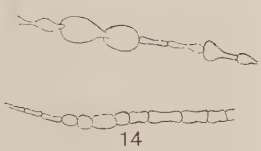
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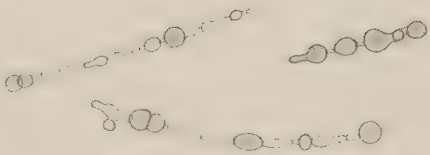

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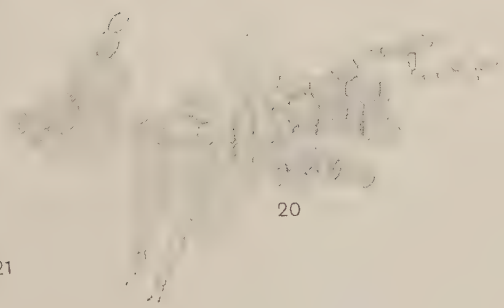
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OBSERVATIONS ON THE "SLIME-FLUXES" OF TREES*.

By Lawrence Ogilvie, M.A., B.Sc. (Abdn.), (late Fullerton Research Scholar, Aberdeen University; Government Plant Pathologist, Bermuda).

(With one text figure.)

INTRODUCTION.

At the suggestion of Mr F. T. Brooks the writer undertook, in the autumn of 1921, the investigation of certain peculiar exudations from the trunks and branches of trees, especially elms, horse-chestnuts, apples and willows. These have long been known in scientific literature under the name of "slime-fluxes" (German, "Schleimfluss") but it might be preferable, on account of the possible confusion of the term with the popular name for the Mycetozoa, to refer to them as "mucilaginous exudations" (French, "écoulements muqueux des arbres") or the "weeping" of trees. The latter term appears to be in use in England.

REVIEW OF LITERATURE.

The first papers on the so-called "slime-fluxes" were published by Dr F. Ludwig of Greisz in the year 1886(1, 2), and dealt with a peculiar pathological appearance on oak trees, from the bark of which there flowed out a beer-like froth in considerable quantity. This he called the "alcoholic flux" or "white slime flux" of oaks.

In 1888 a paper by Ludwig(3) announced the discovery of a new kind of flux, the "brown flux" of apple-trees, horse-chestnuts and elms.

There next followed communications by Hansen(4) and Lindau(5), and, in 1896, a survey by Ludwig of the work accomplished up to that year(6). A useful summary of Ludwig's work up to 1897 will be found in Tubeuf and Smith's text-book(7).

In the same year a note from Massee appeared in the *Kew Bulletin* on the occurrence of the brown flux on fruit trees in England(8).

A long series of communications was published by Holtz in 1901(9), in which he dealt thoroughly with the whole question. A complete bibliography up to that date was appended.

In 1906 a short note on the slime flux of beech trees appeared in the *Journal of the Board of Agriculture*(10), while Massee(11), in 1907, recorded the occurrence of the white flux at Kew.

* Part of a dissertation submitted for the Degree of M.Sc. at the University of Cambridge, 1923.

An inaugural dissertation was delivered in 1910 by Ludwig Rose at the University of Berlin on the subject of the oak slime-flux, but the writer has been unable to consult this.

VARIETIES OF FLUX INVESTIGATED BY THE WRITER, AND METHODS EMPLOYED.

1. *Brown slime-flux*: (*a*) red variety (elms and horse-chestnuts); (*b*) brown variety (elms and horse-chestnuts); (*c*) apple flux.

2. *White slime-flux*: willows and elms.

Samples were taken from as near the fluxing aperture as possible by means of a sterile wire contained in a sterile glass tube. Bouin's picroformol solution and Gram's iodine were found to be the most useful fixatives for smears, while iron alum-haematoxylin gave very satisfactory results as a staining reagent.

BROWN SLIME-FLUX.

1. Previous Investigations.

According to Ludwig(3), this flux occurs on apples, horse-chestnuts, birches, poplars, elms, hazels, tulip-trees, oaks, etc., and is widespread throughout France, Belgium and Germany. It is said to cause much damage to orchard trees and to trees in streets and parks. It is stated to occur all the year round, in this respect differing markedly from the white slime-flux, and is characterised by the outflow of a yellowish brown, viscid, but not gelatinous slime, which originates in the wood, breaks through the bark and flows down the tree in a broad stream.

The constituents of the flux are stated by Ludwig to be the same in all the trees investigated. "The fresh slime contains at first only micrococci, which are accompanied by a mycelial fungus, *Torula monilioides* Corda....The chief role doubtless falls to the bacteria, which I have named *Micrococcus dendroporthos* Ludw. In the later stages there are found numerous other organisms, especially *Fusarium*, large brown spores resembling the teleutospores of a *Puccinia*, and which probably belong to an Ascomycete, algae (Bacillariaceae, Protococcaceae, etc.)"(6). The presence of a mite, nematodes, insect larvae, rotifers, etc., is also recorded. An *Oidium* was found in a horse-chestnut flux.

Ludwig states that the bark is usually entirely destroyed, while the wood becomes rotten and contains free butyric acid. Holtz(9), on the other hand, found that in most cases the tree showed signs of wounding (frost-cracks, insect and other wounds) at the point of origin of the flux and that "nowhere was there any evidence of a destroying effect of the slime-flux on bark or wood."

2. Red Variety.

(a) *General.*

This flux is rather conspicuous on account of its bright apricot-red colour. It occurs very commonly around Cambridge on young Huntingdon elms (*Ulmus vegeta* Schneider), but specimens somewhat resembling this type (and also characterised by the presence of a red colour) have been found on *Ulmus campestris* L. and on the Wych elm (*Ulmus glabra* Hudson = *Ulmus montana* Stokes) in the north of Scotland. It has also been found on horse-chestnuts, and once on a beech tree.

Fig. 1. Red slime-flux exuding from exposed wood on trunk of *Ulmus campestris*.

In very many cases the flux exudes from frost-cracks or cracks at the forks of branches, but not uncommonly it can be seen to flow from the heart wood of a stump where a branch has been cut off. In this it resembles the true brown flux to be described later. In every case of the red flux which the writer examined the exudation flowed from the wood and not from the bark.

The flux is active all through the year, but most strikingly so in spring and early summer, at which periods also the red colour is most pronounced. It is of a soft flabby nature but is much firmer than the true brown flux, which, however, it resembles in its penetrating musky odour. No smell of butyric acid was evident, as was noted by Ludwig.

The accompanying photograph (fig. 1) shows the typical appearance of an old red flux. The tree in question (*Ulmus campestris*) is on the edge of a field and on the side next the field the base of the trunk has been totally denuded of its bark by horses. From the wood, which has become hard and stony to the touch (owing to the deposition of calcium carbonate), a large flux is exuding.

These fluxes were found in all sorts of exposures, but appeared to be slightly more prevalent in damp and shady situations.

We shall consider later the question of the possible causative organisms.

(b) *Organisms present.*

The organism most characteristic of the red flux is a species of *Fusarium*; this gives it its red colour. The red masses flowing from the trees are practically "pure cultures" of the *Fusarium*, and consist of mycelium and spores.

Very frequently an *Oospora* (*Oidium*) of the "*Oidium lactis*" type, but peculiar in certain respects, is found accompanying the *Fusarium*.

The presence of large numbers of bacteria which form fluorescent colonies is noticeable.

A. *Fusarium.*

This fungus is easily isolated from the red flux by plating it out on such a medium as Dox's agar.

Cultural characters. On Dox's agar, beer-wort agar, bran agar, oatmeal agar, meat-extract agar, sterile horse-chestnut twigs, sterile potato slants, sterile *Lathyrus* stems, chunks of elm wood are produced abundant moist slimy "pionnotes" or macroconidial masses, with a sparse, very fine, transparent, cream-coloured or seashell pink (R)* mycelium. Pionnotes varying in colour through carnelian red, rufous, apricot orange and their hues (12, Plate XIV). Marked tendency to mycelial growth in depth of medium. Substratum not discoloured. On steamed rice a very poor growth of pale flesh coloured or flesh coloured (R) mycelium and practically no pionnotes.

Morphological characters. No microconidia found. Macroconidia on aerial mycelium or pionnotes, typically triseptate; one end almost straight and tapering, and the other bent at an angle of about 30 degrees to the main axis of the spore. Spores borne on short pedicels and very constant in size and shape, the average dimensions being $23{\cdot}4 \times 3{\cdot}2\,\mu$. Hyphae average $2{\cdot}5\,\mu$ in diameter, tending to interlace by means of cross connections; terminal and intercalary chlamydospores not uncommon.

* (R) denotes that the colours have been matched as closely as possible in Ridgway's "Colour Standards."

B. *Oospora* (*Oidium*) *lactis* var. I.

This accompanies the *Fusarium* fairly constantly.

Cultural characters. Produces a beautiful colony on beer-wort gelatine at room temperature, consisting of a central zone of irregular wavy lines from which there extend outwards towards the circumference undulating radial lines. Surface powdery (owing to production of aerial conidia). On rich, moist media such as sterile carrots, moist beer-wort agar, etc., a slimy yeast-like growth. In neutral beer-wort no fermentation or surface film after six weeks.

Morphological characters. Branching usually as in *Oospora* (*Oidium*) *lactis*. Primary hyphae 8·5–13 μ, av. 11 μ, secondary or branch hyphae 2·5–6·5 μ in diameter. Hyphal cells rectangular with somewhat rounded ends, up to 100 μ long. Conidia on primary and secondary hyphae in erect chains, conidiophore short or absent. Ends of hyphae breaking up into oidia, 3·5–11 μ × 2·5–5·5 μ (av. 7 × 3·5 μ), rarely globular. Chlamydospores produced abundantly on short stalks from the hyphal cells after seven days on beer-wort agar at 26° C. Diameter when ripe about 11 μ. Spore wall double.

This form of *Oospora* (*Oidium*) *lactis* appears to be distinct from any of those described by Erwin Schnell (13).

C. *Other organisms.*

As already stated the *Fusarium* and *Oospora* occur with remarkable constancy. Other fungi are comparatively few in number. The writer has found *Trichothecium roseum* (Pers.) Link and the blue *Fusarium* strain found in the typical brown fluxes. Protozoa, insect larvae and algae are not so common as in these.

3. Brown Variety.

(a) *General.*

This type of flux has been found very commonly in and around Cambridge on elms, especially on *Ulmus campestris* and *Ulmus vegeta*, and on horse-chestnuts. It frequently occurs on *Ulmus montana* in Aberdeenshire.

So far as the writer's observations go, it is always associated with some wound, such as abrasions of bark due to animals, frost cracks, wounds made by nails, branch snags, etc. It appears to have its origin in the heart wood, and consists of a thick brown or yellowish brown fluid, somewhat of the consistency of porridge.

In the case of branch scars the flux begins as a somewhat copious exudation of a clear watery fluid from the heart wood. This fluid is soon invaded by bacteria, fungi and yeasts, such as *Isaria*, *Torula*, *Alternaria*, pink yeasts, etc. After about a

year, however, the flux is somewhat gritty owing to the presence of crystals of calcium carbonate dissolved from the cell walls of the wood and redeposited in the flux, and contains certain characteristic fungi. In very old fluxes few fungi are found and the brown porridge-like masses are composed mainly of small pieces of disintegrated wood. Insect larvae are abundant, and very characteristic. Protozoa, nematodes, etc., are also common.

The writer is much indebted to Dr D. Keilin, of the Molteno Institute for Research in Parasitology, Cambridge, for the following list of the insect larvae found in a brown flux at Cambridge which are typical:—

Dasyhelea obscura Winnertz (Ceratopogonidae), *Mycetobia pallipes* Meig. and *Rhyphus fenestralis* Scop. (Rhyphidae), *Phaonia cincta* Zett (Anthomyiidae), *Aulacogaster rufitarsis* Mcq. (Ephydridae), *Systenus adpropinquans* Loew. (Dolichopopidae), and an Eristaline (Syrphidae). A mite, *Hericia hericia* (Robin) Kramer (Acarina, Tyroglyphidae), was very common. Some very interesting parasites were found in certain of these larvae*.

(b) *Organisms present.*

A. *Oospora* sp. (?)

This is one of the most interesting of the organisms which have been isolated from the slime-fluxes. It occurs constantly in the brown fluxes of elms and horse-chestnuts.

Cultural characters. On potato agar, Dox's agar, etc. small compact colonies appear after four or five weeks. On beer-wort agar rapid growth (appears after five days at 26° C.); on this medium and on sterile carrot somewhat hard sand-coloured masses or nodules are formed which become white and flocculent when old and dry.

Morphological characters. As it appears in the flux, the fungus consists of strings of oval to globular cells, about 5·5 μ in diameter, with large vacuoles. Cell multiplication is by budding. The white flocculent growth on carrot and other media consists of branching aerial hyphae arising from a creeping mycelium, the cells of which, however, are little different from the ordinary budding cells.

The fungus appears to agree with the somewhat meagre diagnoses given by Ludwig and others of *Torula monilioides* Corda, except in the fact that on no culture media has the writer observed any brown colour microscopically, such as was described by Ludwig. A brown colour has occasionally been noticed in certain of the cells in the crude flux, but this is probably due to staining or to a moribund condition of the cells.

* See Keilin, D., in recent numbers of *Parasitology*.

Holtz (9, p. 184) stated that he had been unable to find *Torula monilioides* in the brown fluxes which he investigated.

If the fungus remains entirely colourless on nutrient media, as the writer's cultures seem to show, it should probably be placed in the genus *Oospora*.

B. *Oospora* (*Oidium*) *lactis* var. II.

Strings or clumps of globular cells very similar to the cells of the fungus described above may be distinguished from them by the production in a hanging-drop culture of the hyphae characteristic of *Oospora* (*Oidium*) *lactis*. They are not found constantly in the brown flux.

Cultural characters. Giant colony on beer-wort gelatine after ten days practically indistinguishable from that of *Oospora* (*Oidium*) *lactis* from milk. The surface is covered by long white flocculent aerial hyphae. In neutral beer-wort no fermentation or surface film but a copious slimy deposit of hyphae. No marked smell. After two days at 26° C. acid is produced from a peptone solution + one per cent. lactose and glucose respectively*.

Morphological characters. Branching as in *Oospora* (*Oidium*) *lactis*. Cells of aerial hyphae 80 × 3·6 μ. Oidia from the moist area in the centre of a ten days' colony on beer-wort agar average 8·3 × 2·8 μ, of the usual rectangular shape with rounded ends. These may swell up before germination into spherical bodies 7·4 μ in diameter.

The young colonies are beautifully arborescent. From the extreme ends of the hyphae very fine transparent filaments grow down into the medium. The cells of these average 2·8 × 60 μ.

The fungus is evidently closely related to the typical *Oospora* (*Oidium*) *lactis* of milk.

C. *Sporing Yeast.*

Accompanying the forms A and B there occurs very frequently a large globular or somewhat elliptical yeast which spores very freely. It is found at all times of the year and in every case a large percentage of the cells are in the sporing condition.

Cultural characters. On beer-wort gelatine (ten days at room temperature) a very moist, white, raised growth. Separate colonies are perfectly round, and of a similar consistency. Acid is produced from glucose after 14 days at 26° C.

Morphological characters. Cells from a twelve hours' beer-wort culture at room temperature oblong with rounded ends to globular, 5·4–9 μ × 2·7–7·2 μ. Spores eight, usually oblong 5·4 × 3·6 μ. Ascus membrane finely verrucose. Division of cells

* 1 % Witte's peptone, 0·5 % NaCl, 1 % lactose, etc.

by means of a cross septum. No mycelium or conjugation observed.

The yeast belongs to the genus *Schizosaccharomyces*. It somewhat resembles *S. octosporus* Beijerinck in the shape of the cells and spores, in its rapid sporulation, and in the absence of a film on beer-wort cultures, but differs from it in the absence of conjugation phenomena, and of fermentation with lactose, laevulose and mannite.

D. *Fusarium.*

Five-septate *Fusarium* spores are frequently found in the brown slime-flux. These belong to a group which discolours sterile potato plugs and produces buff coloured pionnotes and blue sclerotia on culture media.

Morphological characters. Five-septate macroconidia almost straight, but with a crook at one end; from a steamed *Lathyrus* stem 40–55 μ (av. 46 μ) × 5·4 μ. Four-septate spores 37–47 μ (av. 41·4 μ) × 4·5 μ. Microconidia produced on verticillate or simple conidiophores, the latter about 50 μ long. Microconidia ellipsoidal about 7·2 × 2·5 μ, but varying greatly in size and shape. Intercalary chlamydospores have been observed.

E. *Other organisms.*

Verticillium cinnabarinum Reinke et Berthold (formerly *Acrostalagmus cinnabarinus* Corda) occurs very commonly on plate cultures from old fluxes, especially in winter and spring. A white *Sporotrichum* which was very common is probably identical with *S. carnis* Brooks and Hansford (15). *Trichoderma lignorum* (Tode) Harz was frequent on old fluxes of elms and horse-chestnuts. *Cephalosporium* and *Penicillium* species were common. *Dematium pullulans* and non-sporing pink yeasts also occurred commonly during the winter months.

Chlorella vulgaris Beiker and *Protococcus viridis* Ag., algae found on the trunks of trees, apparently grow saprophytically in the flux. They could be isolated from all the brown fluxes by means of Detmer's solution and Detmer's agar. It was discovered, however, that the *Chlorella* was able to grow luxuriantly on ordinary culture media, such as potato agar, Dox's agar, beer-wort agar, etc.

Ludwig (16) describes two new species of algae from the slime-fluxes, but we have not seen any form to correspond with his descriptions.

4. Apple Flux.

(a) *General.*

A flux has been noticed on branch wounds of apple-trees in and around Cambridge, which appears to have a very typical flora. It seems to be more prevalent on certain varieties of

apples than on others; thus "Lord Grosvenor" appears to be somewhat susceptible, although similar fluxes have been found on trees of "Newton Wonder," "Chivers' Seedling" and "Duchess of Oldenburg."

The fluxes are white, pale pink, or black in colour, of a watery or slimy consistency, and proceed entirely from the centre of the wood of the cut branch. They are prevalent all through the year, but tend to dry up during the summer. They apparently do little damage to the trees except after a prolonged period, when rotting of the wood and bark takes place slowly.

According to Ludwig(17), the fluxes of apple-trees are practically the same as those found on elms and horse-chestnuts. The writer has found, however, that, around Cambridge at least, they have a peculiar and interesting flora of their own, composed of three kinds of yeasts. Fluxes have never been seen on plum-trees, as described by Massee(8).

The apple fluxes appear to originate as a physiological exudation similar to that described in the brown fluxes of elms.

(b) *Organisms present.*

A. *Yeast I.*

Cultural characters. On beer-wort gelatine after 14 days a flat white growth with a wavy edge, central raised portion, and radial lines. No liquefaction. Growth on agar very similar. On beer-wort a film is formed after 24 hours at 26° C. No fermentation. Acid from glucose (14 days). No spore formation. Marked growth at 1° C.

Morphological characters. On solid media and beer-wort, film hyphae are formed. Cells 10 × 1·8 μ, branching irregularly by budding. Separate cells from a three days' culture on beer-wort gelatine average 9 × 4 μ and are vacuolate.

B. *Yeast II.*

Resembles Yeast I in appearance.

Cultural characters. On beer-wort gelatine forms small round grey colonies with slightly raised white centre with crater-like markings, deep radial furrows and indented edge. The young colonies have beautifully branched hyphae at the edge. Does not liquefy gelatine. On beer-wort after 24 hours at 26° C. a thick grey surface film is formed. No alcoholic fermentation or spore formation. Acid produced from glucose and laevulose after 14 days.

Morphological characters. Resembles Yeast I, but cells average 3·5 μ in diameter. From a five days' beer-wort film the cells measured 9 × 3·6 μ.

C. *Yeast III.*

Cultural characters. Ten days' beer-wort gelatine slant at room temperature—a moist white growth with radial wrinkles extending from a central raised area. Separate colonies are whitish, raised, and have a chalky white central boss when old. Surface film and copious deposit in beer-wort, but no alcoholic fermentation. No spore formation.

Morphological characters. Cells spherical with large vacuoles. Diameter, from a three days' beer-wort gelatine slant, 1·8–5·5 μ, average 3·7 μ.

The three yeasts must be placed in the genus *Torula* Turpin.

D. *Other organisms.*

The black colour of many of the apple fluxes is due to short hyphal strands and strings of cells of a dark brown or black colour which belong to *Dematium pullulans*, a fungus which is common on the bark of apple-trees. Ludwig refers to the presence of "large brown spores resembling the teleutospores of a Puccinia." These are probably the chlamydospores of this fungus.

A *Cephalosporium* sp. appeared very commonly on the culture plates, and, less commonly, species of *Torula*, *Penicillium*, *Sporotrichum* and pink yeasts. Fluorescent bacteria were very frequent. A large variety of *Oospora* apparently identical with *Oospora Ludwigii* (Hans.) Sacc. et D. Sacc., to be described later from the white flux of willows, was isolated from an apple flux from Meldreth.

Algae (*Protococcus*, etc.) were present in small quantity. Insect larvae and protozoa were not usually found.

WHITE SLIME-FLUX.

1. Previous Investigations.

The so-called "alcoholic flux" or white slime-flux was found by previous investigators on oaks, birches, poplars, beeches, willows, maples and ashes. It is said by Ludwig to result in a complete fermentation of the bark, bast and cambium, and sometimes a part of the wood. The destruction and fall of the bark often accompanied a marked diminution in the growth of the tree(6). It was often found associated with branch scars, frost cracks, goat-moth borings and other wounds, but apparently sprang also from the uninjured bark. It usually occurred on the main trunk of the tree.

Its duration was from June to August, and the time of its appearance was very constant each year. The strong smell of beer and later of malic ester and vinegar attracted large numbers

of hornets, stag beetles, wasps, bees and flies which fed ravenously on the frothy exudations and evidently suffered somewhat from intoxication in consequence. Ludwig attributed to them the dispersal of the flux.

The initial fermentation is brought about, in Ludwig's opinion, by a fungus which he named *Endomyces Magnusii*, and which forms asci resembling those of yeasts. In its mycelial form it resembles a large *Oospora* (*Oidium*) with preponderating unilateral branching. This is accompanied by *Saccharomyces Ludwigii* Hansen, a yeast regarded at first by Ludwig as a stage of the Endomyces, and, according to Ludwig by *Leuconostoc Lagerheimii* Ludw., a bacterial form, somewhat resembling *L. mesenteroides* Cienkowski, the "frog-spawn" of sugar factories.

Hansen (4), in Denmark, was unable to find these three organisms except in one case out of seventeen. Holtz (9), near Karlsruhe, found the oak fluxes only on the main trunk and usually somewhat low down. They started to flow in May and June and had all stopped by the first half of August. He found that an *Oidium*, resembling the *Oidium* stage of Ludwig's *Endomyces* was occasionally, though not constantly, present He could not identify *Leuconostoc Lagerheimii*.

2. White Flux of Willows.

(a) *General.*

At the end of May, 1922, and again in 1923, curious exudations were noticed on the trunks of pollard willows on the banks of the Cam near Cambridge. They flowed in every case from cracks and small holes on the main trunk, often near the ground, were very frothy, pure white in colour, and had a strong smell of beer. Numerous ants and small flies had evidently been attracted by the smell and were crawling over and feeding on the fluxes.

These exudations remained active till about the middle of July, when they became more slimy and finally dried up, leaving rusty brown marks. In the later stages they were much visited by wasps and hornets, and contained insect larvae. In comparison with the brown fluxes their volume was very small, and no damage was done beyond a slight disintegration of the bark, to which they were apparently totally confined.

(b) *Organisms present.*

A. *Oospora* (*Oidium*) sp. (probably = *Oospora Ludwigii* (Hans. Sacc. et D. Sacc.).

The oidia and hyphae of this fungus were found in most of the specimens of white flux of willows which the writer examined, but it was not universally present, and the greater part of the

substance of the fluxes was composed of bacteria, especially in the later stages. This organism is however responsible for the frothy nature of the fluxes.

Cultural characters. Easily isolated on beer-wort agar and gelatine and grows well on these media, giving a colony with a white powdery centre whence the hyphae and oidial chains extend radially towards the circumference. Gelatine is liquefied after ten days at room temperature. On carrot a white slimy yeast-like growth is formed. Beer-wort undergoes alcoholic fermentation after 24 hours at 26° C. A surface film is formed and later a copious deposit.

Morphological characters. Resembles *Oospora* (*Oidium*) *lactis* in budding; it has however a tendency towards unilateral branching. Cells 40–100 × 10 μ, breaking up by cross septation into oidia, which decrease in size towards the circumference of the colony and may there be spherical. In liquid media these oidia may multiply by cross-septation like a *Schizosaccharomyces*, and certain cells may become transformed into thick walled chlamydospores. Spherical chlamydospores from a four days' culture on beer-wort varied from 7 to 16 μ in diameter, with a wall 1·8–3·8 μ thick.

The fungus agrees closely with the diagnosis of *Oospora Ludwigii* (Hans.) Sacc. et D. Sacc. Endogenous spores have not been seen by the writer (in common with Holtz). The fermentation of beer-wort and the formation of a surface film are in agreement with Holtz's observations. The presence of a sweet smell, suggesting an ester, coincides with the observations of all investigators.

The writer has not been able to induce the fungus to form asci. This is in agreement with the findings of Holtz and Hansen, and partly with those of Brefeld, who encountered both ascigerous and non-ascigerous strains. Lorrain Smith and Ramsbottom (18), on the other hand, recorded the presence of asci in a pure culture isolated from "exudations of various trees," while Guilliermond found asci in only about three per cent. of his cultures (19).

B. *Sporing Yeast.*

A round sporing yeast was found very commonly in the white fluxes of willows, especially in their later stages.

Cultural characters. On beer-wort gelatin and agar a flat white colony with radial lines extending from a raised centre. Gelatine is slowly liquefied. In beer-wort (seven weeks old) no film is produced, but a copious deposit. No alcoholic fermentation. Acid was formed from glucose and maltose.

Morphological characters. Cells usually globular, multiplying

by budding, and average 5·4 μ in diameter from a three days' beer-wort gelatine culture. Spores formed readily on ordinary media, four in number, globular, and about 1·8 μ in diameter. No mycelium or conjugation observed.

The yeast belongs to the genus *Saccharomyces* Meyen.

A similar flux was found on certain Huntingdon elms near Jesus College, Cambridge, which died off one by one probably owing to an escape of gas from a main in the vicinity. The flux appeared in July as large gelatinous masses exuding from bore-holes of the bark-beetle, *Scolytus*, with which the trees were badly infested. Large numbers of wasps were attracted to the exudations, which were confined to the bark and persisted only for a few weeks. Neighbouring healthy trees were unaffected. The organisms present included bacteria with gelatinous sheaths and a round sporing yeast identical with that described from the flux of willows.

GENERAL DISCUSSION.

The brown flux is, when gathered near its point of exit from the tree, of a watery nature, but after exposure to the air for some time it dries up to a yellowish brown or brown powder. It is not hygroscopic. The red flux of Huntingdon elms was found to be slightly alkaline, having a *p*H of about 9, while advanced brown fluxes from *Ulmus campestris* were more alkaline, with a *p*H of from 9 to 9·5. The alkalinity is probably due to the large amount of calcium carbonate derived from the wood (the ash of elm wood is stated to contain 47·8 per cent. of lime). This also accounts for the hard stony nature of old flux marks.

The writer has come to the conclusion that the red and brown fluxes are of physiological origin, arising primarily, in the case of branch wounds, as the exudation of a clear fluid from the centre of the heart-wood. Such water-soaked areas have been seen by the writer in the centre of freshly-cut branches of Huntingdon and Wych elms during the summer months. They do not occur on small branches in which no heart-wood is evident, but are very commonly to be seen on exposures of large branches. Similar water-soaked areas have been seen in the centre of cut branches of apple and poplar.

There is little doubt that these phenomena are the same as those investigated by Professor W. G. Craib in the case of *Acer* (20), and later in the case of true heart-wood trees (*Ulmus montana* and *Quercus cerris*) (21). According to Prof. Craib, storage of water takes place in the autumn in the centre of the trunk, commencing at the base. "By the time the centre has received its quota far up the trunk another movement has begun causing

a re-arrangement at the base, and leaving the centre as the driest region." The present writer's observations go to support these conclusions. Water-soaked areas appear first of all in the branch stumps in early spring and in most cases spread gradually towards the circumference. Central water-soaked areas have been noticed, however, in early autumn, and it is remarkable that the fluxes are active practically all the year round. Prof. Craib suggests that there might also be summer water-storage.

All stages have been traced between these water-soaked areas and the typical flux; at least a year appears to be necessary for the development of the latter. The clear fluid exuding from the water-soaked areas is alkaline (*p*H about 9) and flows in greatest quantity during hot weather*. Sugars are either absent or occur only as traces.

The medullary rays and wood parenchyma of the water-soaked wood are full of a gummy substance, partly tannin and partly starch, which gives the wood a brown colour. In the later stages of the flux the vessels may be invaded by hyphae and bacteria, in which case both vessels and parenchymatous cells become filled with gum. The bark surrounding old fluxes becomes blackened superficially.

It is possible that in the case of wounds on the trunks of trees, brown fluxes may develop from a simple sap-flow. Sap-flows from artificial bore-holes in horse-chestnut trees quickly developed some of the typical insect-larvae and fungi, but the flow was not so constant as in the case of heart-wood exudations.

Numerous inoculation experiments were carried out but in no case did a typical flux appear within the time available.

In order to discover if possible any noticeable effect of these organisms on wood tissues and cellulose, cultures were made on sterile wood blocks, twigs, sawdust, sawdust and nutrient solutions, sterile filter paper, cellulose and filter paper agars, etc., etc. These experiments showed that none of the organisms (fungi, yeasts, and bacteria) have any marked disintegrating action on woody or cellulose tissues. This might have been expected, since no decomposition of wood or bark takes place except after prolonged periods.

The white fluxes are totally confined to the bark and without doubt arise in the phloem. Willow fluxes were distinctly acid (*p*H 6 to 6·7). No sugars were detected in these, but somewhat similar white fluxes of *Ulmus campestris* were distinctly sticky and contained large quantities of glucose. Exudations of this nature are not uncommon from the bark of trees which have

* About 0·75 c.c. was collected in half-an-hour.

been injured in some way and are probably to be attributed to an accumulation and subsequent outflow of phloem materials. Yeasts and bacteria with gelatinous sheaths develop very rapidly in these exudations. Inoculation experiments of the organisms on healthy bark were unsuccessful, so that here again we must conclude that the flux is of physiological origin. Nothing abnormal was found in the constitution of the tissues from which the fluxes originated (*cf.* Holtz(9), p. 126).

The practically constant occurrence of the fungoid and yeast forms described in the case of both brown and white fluxes is rather remarkable, and must be attributed to the nature and reaction of the food supply.

The difference between the constituents of the fluxes found by the writer and those described from the Continent are rather marked. This coincides somewhat with the observations of Hansen and tends to support the view that the fungi and yeasts are of no importance as causative agents.

If the writer's theory concerning the origin of the slime-fluxes is correct, it would suggest the futility of painting or tarring wounds of trees from which fluxes are already flowing. Apple-trees have been noticed on which fluxes on the branches have broken through a thick coating of tar.

As suggested by previous workers, the flux material may prove deleterious to the tree by inducing the growth of spores of such fungi as *Polyporus squamosus* and *Collybia velutipes*. The writer has often seen the fructifications of *Collybia* associated with fluxes on elm.

In conclusion I wish to express my warmest thanks to Mr F. T. Brooks at the Botany School, Cambridge, under whose supervision these investigations were carried out, for much personal help, and encouragement on all occasions.

SUMMARY.

1. Investigations have been carried out on certain peculiar exudations from the trunks and branches of elms, horse-chest-nuts, apples, willows, etc.

2. The reddish flux of Huntingdon elms was found to be composed of a *Fusarium* forming copious pink spore-masses, an *Oospora* (*Oidium*), bacteria, and other casual organisms.

3. The brown flux of elms and horse-chestnuts invariably contained a species of *Oospora*. An *Oospora* (*Oidium*), a sporing yeast and a *Fusarium* were commonly found, but not constantly. It also contained fluorescent bacteria, algae, insect larvae, etc.

4. The flux of apple trees, found in and near Cambridge, always contained three kinds of non-sporing yeasts.

5. The white flux of willows contained an *Oospora* (*Oidium*)

probably identical with *Oospora Ludwigii* (Hans.) Sacc. et D. Sacc., a sporing yeast and bacteria.

6. The first three kinds of flux persisted throughout the year. In the case of elms at least the flux originated in a watery exudation from the heart wood which appears to be connected with water storage in the wood.

7. Large amounts of calcium carbonate were present in the red and brown fluxes. This is derived from the vessels of the wood and renders the reaction of the exudation favourable to the growth of organisms.

8. The white fluxes originate in the bark and are always associated with wounds or an unhealthy state of the tree. They are more acid than the brown fluxes and last only for a short time in the summer months.

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NOTES ON RHYTISMA ACERINUM AND RHYTISMA PSEUDOPLATANI.

(With Plate VII.)

By Rose Bracher, M.Sc.

Introduction.

During an investigation of the cytology of the genus *Rhytisma*, several observations relating to the general life-history have been made which have not hitherto been recorded. The object of this paper is to give a preliminary account of these observations which may serve as an introduction to the cytological study.

The material used for investigation has been collected in England and the United States. The English form growing upon *Acer Pseudoplatanus* L. is separated by Müller (1913) as a new species, *R. Pseudoplatani*, while the American form, found on *Acer saccharinum* Wangenh., the common maple of the United States, is called by Müller *R. acerinum*. The life-histories of the two forms studied are closely similar, and the few minor differences which occur will be noted below.

External Appearance.

It may be of interest to record briefly the successive changes in external appearance which occur on infected leaves. Leaves were inoculated and closely watched for symptoms. It was found that the incubation period corresponded with that given by Müller; the first indication of the disease being minute water-soaked dots which rapidly develop into small yellow spots about 1–2 mm. in diameter. Four or five days later, on the upper surface of the leaf, minute black dots appear within each yellow spot, and these spread and finally coalesce until the spot becomes uniformly black. At first the black spot is smooth but in a few days it becomes covered with a number of small pimple-like projections about 1 mm. in diameter. These open at the top by a circular pore through which small drops of a milky fluid are exuded. This is the conidial stage of the fungus, and under natural conditions lasts from June until August. When this stage is over the spot begins to thicken and extend in area so that when the leaf falls the average diameter of the spot is about 1·5 cm. The surface of this spot is smooth at first but during the winter, when the leaves lie on the ground, it becomes raised into sinuous ridges which indicate the positions of the

developing apothecia. In the spring these ridges rupture along their crests by longitudinal fissures which expose the white hymenium beneath.

Internal Appearance.

For the purpose of studying the development of the parasite in relation to its host, fixations of material were made each week. The preparations were cut with a microtome at a thickness of 5 μ and stained with various modifications of Flemming's Triple Stain.

1. *Infection.* Infection as noted by Müller is produced by means of the ascospore. This adheres to the under surface of the leaf by means of its gelatinous sheath and if near a stoma sends out a germ tube which grows through a stomatal pore. The fungus branches sparingly in the air spaces, lower epidermis and spongy mesophyll of the leaf. It is, however, intra-cellular and ramifies throughout the cells of the palisade tissue, becoming especially concentrated in the cells of the upper epidermis. Here, further growth of the hyphae, chiefly in the vertical direction, causes a pressure upon the inner and outer walls of the epidermal cells and a consequent rupture of the vertical walls (fig. 1). This does not agree with the observations made by Müller, who states that the hyphae are not in the cells of the upper epidermis but that the fungus develops between the cuticle and the cell walls. Further, it is possible to see, in this and subsequent stages of the fungus, the cuticle still in contact with the outer epidermal walls. This stage in the life-history may be regarded as the end of the incubation period and corresponds with the appearance of the yellow spots on the leaves.

2. *Sclerotium.* In sections cut when the dotted black sclerotia are visible on the leaves, the outer cell walls of the upper epidermal cells exhibit a conspicuous blackening. The cells themselves are rich in a fatty brownish material which, it would appear, is secreted by the hyphae and laid down upon the cell wall which gradually changes from brown to black (fig. 2). The sclerotium remains in this condition during the summer or conidial stage of the fungus. During the formation of the apothecia the sclerotium becomes greatly thickened by the activities of the hyphae which form a hard, black, plectenchyma beneath the originally thickened cell walls (fig. 4). Sclerotium formation also occurs to a much lesser extent in the cells of the lower epidermis (fig. 4).

3. *Pycnidia.* The hyphae below the early formed sclerotium become arranged in a vertical series (fig. 2), giving rise to a number of unbranched conidiophores. The contents of these hyphae stain most deeply at the apices and rod-shaped conidia

are developed from them in basipetal succession. The increasing pressure due to the growth of the conidiophore causes a rupture in the wall, and the conidia escape through the aperture (fig. 3).

4. *Stroma.* After the shedding of the conidia, the fungus layer on the leaf thickens considerably by a very extensive growth of the hyphae and the inner and outer walls of the upper epidermal cells are consequently pushed further apart. They are however clearly visible in this widely separated condition in this and subsequent stages of the fungus (figs. 3 and 4). This observation bears out the assertion that the main development of the fungus is actually within these epidermal cells. The hyphae immediately under the thickened outer walls of the epidermal cells give rise, as has been noted, to a sclerotium, and below this is a layer of thin-walled mycelium (fig. 4). Those hyphae which, in this mycelium, are in contact with the inner walls of the upper epidermal cells frequently give rise to a slight development of sclerotium (fig. 4). The relative thickness of the fungus layer and the leaf itself varies in the different forms studied. In *R. acerinum* on *Acer saccharinum* the fungus layer may be from three to four times as thick as the leaf, while in *R. Pseudoplatani* on *Acer Pseudoplatanus*, the fungus layer is only slightly thicker than the leaf itself (fig. 4).

5. *Apothecia.* The hyphae under the sclerotium which at first appear as a more or less undifferentiated mycelium soon undergo a change. Certain groups of vertically arranged hyphae, staining much more readily than the rest, show the beginnings of the hymenium. These groups appear at intervals and around them definite apothecial cavities become marked off by a progressive differentiation of the surrounding hyphae. The hymenium itself develops considerably and during the winter months the distinction between asci and paraphyses is plainly visible. Müller states that this differentiation does not take place until March but it has been seen that the ascus development depends greatly on weather conditions, and while during the hard winters of Wisconsin, U.S.A., there is little differentiation during winter, in the British forms studied and in American forms collected during a mild winter, asci and paraphyses were well differentiated by January. The asci are uninucleate during the greater part of the winter though they increase in size considerably. In the spring when the ascospores are produced within the asci (fig. 4), an interesting dehiscence mechanism has been observed which brings about the splitting of the sclerotium above the apothecium. Small canals appear in the sclerotium and run longitudinally in the ridges above the asci, in the median plane. In transverse section these appear triangular. They contain a clear, somewhat viscid liquid which is apparently produced by the activity of

the hyphae which disorganise the sclerotium in this region. Probably, during the wet periods noted by Müller to be prerequisite for the rupturing of the wall, water passes into this cavity which is bounded by the non-elastic sclerotium. The break naturally occurs where the cavity is widest and the pressure correspondingly greatest (fig. 4).

The actual morphology of the ascospore and the ascus has been fully described by Müller.

Summary.

The foregoing points may be summarised as follows:

1. Infection takes place by means of the germ tube which grows from the ascospore through a stoma on the under surface of the leaf.

2. The fungus branches and penetrates the cells of the leaf chiefly on the palisade layer but finally concentrates in the cells of the upper epidermis.

3. Subsequent development of the fungus takes place actually within the cells of the upper epidermis. The cells are consequently killed and the walls ruptured and pushed apart.

4. Black sclerotium formation is first apparent in the thickened outer walls of the upper epidermal cells and is later increased by the development of a plectenchymatous layer beneath these walls.

5. Splitting of the apothecia is accompanied by the development of a special mechanism whereby the sclerotium is broken down in the region of the split.

REFERENCE *.

Müller, K. Zur Biologie der Schwarzfleckenkrankheit der Ahornbäume hervorgerufen durch den Pilz *Rhytisma acerinum*. Centr. f. Bakt. Abt. 2, xxxvi, p. 67. 1913.

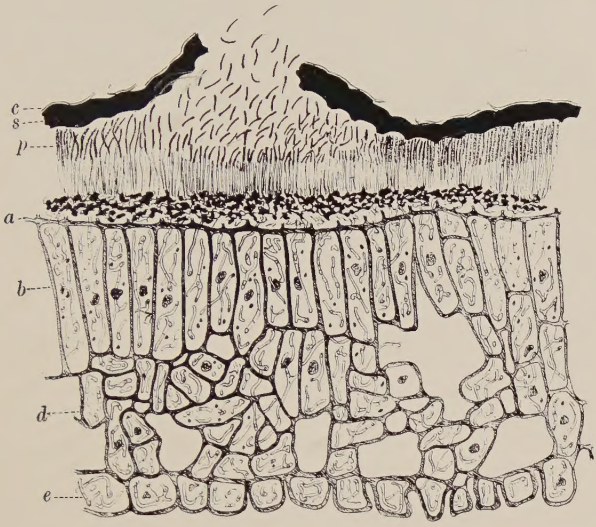
EXPLANATION OF PLATE VII.

Transverse sections through *Rhytisma* spot.

Fig. 1. Early yellow spot stage.
2. Early conidial stage.
3. Late conidial stage.
4. Apothecial stage.

a. = upper epidermis. *b.* = palisade tissue. *c.* = cuticle. *d.* = spongy mesophyll. *e.* = lower epidermis. *f.* = ascus layer. *h.* = hyphae. *p.* = conidiophores with conidia. *s.* = sclerotium.

* A full list of references will be given in a further account of *Rhytisma*.



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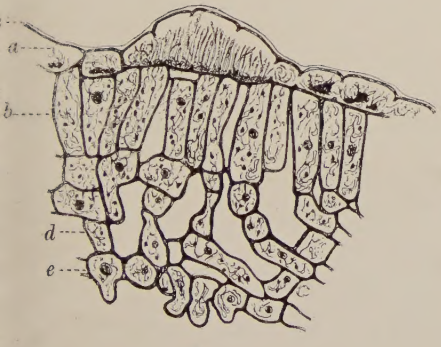

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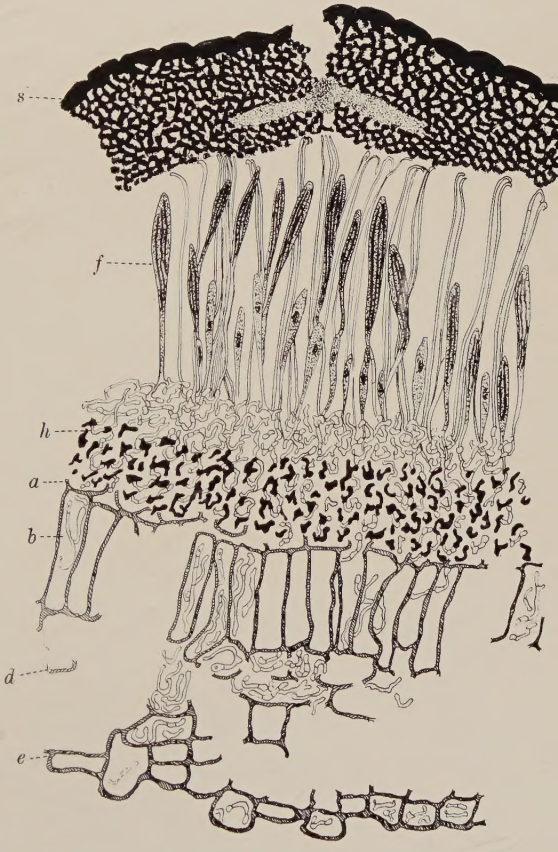

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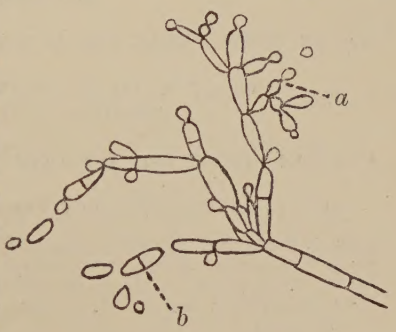
HORMODENDRON OLIVACEUM (CORDA) BON.—A NEW BRITISH RECORD.

By F. C. Ford Robertson, B.Sc.,
Probationer, Indian Forest Service.

(With one text figure.)

The source of the material was some mummy plums infected with *Sclerotinia* sp. collected at Faversham, Kent, in April 1922 by Dr Malcolm Wilson. In the course of making cultures to obtain the *Sclerotinia* an olive-green mycelium was found which bore no resemblance to that of the latter fungus. Pure cultures were obtained from it by spore isolation and the formation of hyphae and conidia studied in a hanging drop of glucose solution. Germination takes place readily, the germ-tube, at first hyaline, becoming septate and olive-green in about thirty hours and sending out branches in all directions. Conidiophores are soon developed in profusion. They are erect, of the same olive-green colour, and are dendritically branched, three or more branches arising from the same point; on these branches, by abstriction, the conidia are formed, in a somewhat irregular catenulate manner; they are unicellular, globose to ovoid, olive-green to fuscous, 4·6–7·5 × 3–5·5 μ and are joined to one another by a slight hyaline neck (see *a* in the figure). There is a tendency for the conidiophore branch, when forming conidia, to break up into short lengths of hyphae with two or three septa, and these latter break up to form the more elongated conidia (see *b* in the figure).



The fungus has been identified as *Hormodendron olivaceum* (Corda) Bon., one of the Dematiaceae. It differs from other species of *Hormodendron* in the mode of production of the conidiophores and in the size and shape of the conidia. The species most resembling it are *H. Hordei* Bruhne and *H. chlorinum* var. *nigrovirens* (Fresen.) Sacc., but the former is characterised by warted conidia, while in the latter there is no hyaline neck uniting the conidia into chains. It differs from *H. cladosporioides* (Fresen.) Sacc. in its almost globose conidia.

H. olivaceum has not been previously recorded in Britain but has been found on the continent growing on birch wood.

PROCEEDINGS, 1923.

AUTUMN FORAY AND ANNUAL MEETING, WINDSOR.
28th Sept.—2nd Oct.

FORAY WITH ESSEX FIELD CLUB, EPPING FOREST. *13th October.*

FORAY WITH BRITISH ECOLOGICAL SOCIETY, BURNHAM BEECHES. *20th October.*

AUTUMN FORAY FOR LONDON STUDENTS, OXSHOTT. *27th October.*

MEETING. UNIVERSITY COLLEGE, LONDON. *17th November.*

Miss R. Bracher. Observations on *Rhytisma*.
Mr J. J. Clarke. Notes on some mycological Chromidia.
Mr W. J. Dowson. A Mould attacking Sweet Peas.
Dr A. S. Horne and G. H. Jones. Further contributions to the study of *Eidamia*.
Mr R. Paulson. Observations on tree Mycorrhiza.
Mr A. A. Pearson. A Foray in Paris.